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FINAL

Site 88 Remedial Investigation Work Plan

Operable Unit No. 15 (Site 88)

Marine Corps Base

Camp Lejeune, North Carolina

Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

Contract No. N62470-95-D-6007

CTO-0250

LANTDIV Clean II Program

July 2003

Prepared by

CH2MHILL

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Abbreviations and Acronyms

AM	Activity Manager
AOCs	Areas of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Above ground Storage Tank
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
bgs	Below Ground Surface
BMI	Battelle Memorial Institute
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPC	Chemicals of Potential Concern
COC	Contaminants of Potential Concern
CRDLs	Contract Required Detection Limits
CSF	Cancer Slope Factor
CTO	Contract Task Order
DCE	Dichloroethene
DEM	Division of Environmental Management
DNAPL	Dense Non-Aqueous Phase Liquids
DoN	Department of Navy
DOT	Department of Transportation
DPT	Direct Push Technology
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EMD	Environmental Management Divisions
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
Fm.	Formation
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
FSP	Field Sampling Plan
FTM	Field Team Leader
FWS	Fish and Wildlife Service
HA	Health Advisories
HASP	Health and Safety Plan
HI	Hazard Index

ICR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRP	Installation Restoration Program
kg	Kilogram
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCB	Marine Corps Base
MCLs	Maximum Contaminant Limits
MDLs	Method Detection Limits
mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
msl	Mean Sea Level
NAIPS	Natural Attenuation Indicator Parameters
NAVFAC	Naval Facilities Engineering Command
NC DENR	North Carolina Department of Environmental and Natural Resources
NCP	National Oil and Hazardous Substances Pollution and Contingency Plan
NCWQS	North Carolina Water Quality Standards
NFA	No Further Action
NWI	Nation Wetlands Inventory
OSHA	Occupational Safety and Health Administration
PCE	Tetrachloroethene
PAH	Polynuclear Aromatic Hydrocarbons
PM	Project Manager
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goals
QA/QC	Quality Assurance/ Quality Control
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RABITT	Reductive Anaerobic Insitu Treatment Technology
RAGS	Risk Assessment Guidance for Superfund
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RRRS	Relative Risk Ranking System
RTL	Review Team Leader

SARA	Superfund Amendments and Reauthorization
SCS	Soil Conservation Service
SEAR	Surfactant Enhanced Aquifer Remediation
SI	Site Investigation
SPLP	Synthetic Precipitation Leaching Procedure
SSC	Site Safety Coordinator
SSI	Supplemental Site Investigation
TAL	Total Analyte List
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
UCL	Upper Confidence Limit
UST	Underground Storage Tank
USC	United States Code
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
VOCs	Volatile Organic Compounds
WQS	Water Quality Standards

1 Introduction

Marine Corps Base (MCB), Camp Lejeune is located in Onslow County, North Carolina. Based on the results of a 1995 four-well site check conducted by OHM, Building 25 was moved to the Installation Restoration Program. Phase I of the RI was conducted in July/August 1996 and Phase II was conducted in April/May 1997. The presence of DNAPL was suspected based on the findings of the RI. NFESC became interested in Site 88 as DNAPL remedial demonstration site in 1997 and visited the site during Phase II work. Interra, Inc. initiated the DNAPL Site Characterization phase almost immediately after the completion of the Phase II work (beginning in July 1997). Some of the findings from that characterization were incorporated into the Final Focused RI Report of May 1998. Due to the discovery of dense non-aqueous phase liquids (DNAPLs) and elevated concentrations of dissolved-phase chlorinated hydrocarbons during the focused RI, CH2M HILL is now tasked to perform a comprehensive RI of Site 88. This Work Plan was prepared to address data gaps in the investigation for Site 88 at MCB Camp Lejeune, North Carolina. The need for additional work is based on the findings presented in the September 2002 Draft Supplemental Site Investigation (SI) Report prepared by CH2M HILL and the May 1998 Final Focused Remedial Investigation Report prepared by Baker Environmental.

CH2M HILL was tasked with submitting this Work Plan under contract with LANTDIV (Contract No. N62470-95-D-6007, CTO-0250 of the LANTDIV Clean II Program). This Work Plan is being submitted to fulfill the stipulated requirements.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process for conducting the Remedial Investigation (RI) is being followed. In addition, the RI activities at Site 88 will address the concerns expressed by the specific standards and acts that will be considered in determining whether additional corrective action is required, specifically the North Carolina state Groundwater Quality Standards.

1.1 Project Objectives and Scope of Work

The primary project objectives are to address the data gaps in the Final Focused RI Report (Baker, 1998), which were identified by the Supplemental SI Report (SSI) (CH2M Hill, 2002), and complete the source identification and delineation of the releases at Site 88.

The scope of work proposed in this Work Plan was developed in accordance with the objectives of the Installation Restoration Program (IRP). The following information was used to develop the scope of work.

- The Final Focused RI Report's descriptions of sampling conducted during 1997 and 1998, which included an evaluation of the nature and extent of contamination at Site 88.
- The 2002 Supplemental Investigation report (CH2MHILL, 2002), and
- The data quality objectives (DQOs) for the site, including appropriate analytical data quality levels, analytical detection limits, critical samples, and quality assurance/quality control (QA/QC) samples. These data quality objectives were designed using the 7 step

DQO process as defined by the Environmental Protection Agency (EPA) (EPA/600/R-96/055/ September 1994).

Soil and groundwater samples will be collected for field screening and laboratory analysis. All soil and new groundwater well samples collected from Site 88 will be analyzed for volatile organic compounds (VOCs), total filtered and unfiltered metals and natural attenuation indicator parameters (NAIPs). Existing wells will be sampled for VOCs, metals and NAIP. Samples will be analyzed within EPA's recommended holding times; however, selected samples will be analyzed on a rapid turnaround basis to assist in making field decisions. With the exception of the NAIPs that must be measured in the field, sample analysis will be conducted in a fixed-base laboratory. Sampling details for the site are provided in the Field Sampling Plan ([FSP]; Appendix A) of this Work Plan.

1.1.1 Investigation Objectives

The investigation objectives for Site 88 are as follows:

- Assess the wastewater conveyance system to document whether it is a source of site contamination. This work will include evaluating the condition of the underground wastewater conveyance system using video camera surveys and conducting soil and groundwater sampling along the sewer lines.
- Assess the horizontal and vertical extent of the chlorinated solvent release in soil and groundwater, and define any existing or residual sources of contamination.
- Investigate the thickness, lateral continuity, and permeability of the lower confining unit for the shallow surficial aquifer beneath the site.
- Evaluate the hydraulic connectivity between the shallow, intermediate, and deep aquifers beneath Site 88.
- Demonstrate that biological degradation is a dominant physical process that is occurring in the shallow aquifer.
- Define any existing or residual sources of contamination.
- Evaluate fate and transport of the chlorinated solvents within soil and groundwater.
- Prepare a Comprehensive Final RI Report summarizing the findings of the investigation.

1.1.2 Scope of Work

The scope of work proposed for Site 88 is as follows:

- Video surveys of the stormwater sewer line and wastewater sewer line will be conducted in order to identify areas of deterioration that may have allowed solvents to leak into the subsurface. The video surveys will be used in conjunction with existing soil and groundwater chemical and physical data to select appropriate sampling locations along the underground utility corridors. Soil and groundwater samples will be collected using direct push technology (DPT) to evaluate the potential for contaminant migration along the utility corridors.
- Since soil sampling last occurred in 1997, near surface soil samples (zero- to 1 foot bgs) will be collected from the grassy area on the north side of Building 25 and analyzed to evaluate potential exposure pathways by direct contact with surface soil. Sampling will

be conducted using DPT. This data will be used to confirm that there has not been a change in conditions in the past 6 years.

- In addition to the DPT borings along the conveyance system, 24 additional borings will be advanced to the lower confining unit for the purpose of delineating downgradient groundwater contamination. These borings will completed under the AGVIQ/CH2M Hill Joint Venture.
- The data gathered from the DPT borings gathered will be used to site permanent monitoring wells. A total of 27 monitoring wells will be installed at locations surrounding Site 88. The purpose of these monitoring wells is to characterize the site lithology, monitor groundwater quality, and evaluate groundwater elevations and flow directions. A total of seven monitoring wells will be installed in the shallow aquifer to depths ranging from 15 to 25 feet below ground surface (ft bgs). Eleven monitoring wells will be installed in the intermediate aquifer to depths of approximately 50-ft bgs. Eight monitoring wells will be installed in the deep aquifer zone to a depth of 85 to 100 ft bgs. One deep well will be advanced to a depth of approximately 150 feet to facilitate vertical delineation of contamination. Discrete soil samples will be collected from the soil borings at regular depth intervals to characterize lithology and screen for the presence of VOCs.
- Geotechnical testing for vertical permeability grain size distribution, and porosity will be conducted using undisturbed soil samples collected by thin-walled Shelby tube samplers from the eight deep well borings and three of the intermediate depth well borings. Shelby tube samples will be collected from the silty aquitard layer (~20-22 ft bgs), the fine sand aquifer (45-47 ft bgs), and the silty fine sand aquitard layer (~70-72 ft bgs) for each deep boring where they are encountered. Undisturbed samples will be taken from the silty aquitard layer and the fine sand aquifer for the three selected intermediate wells if they are encountered.
- Groundwater samples will be collected from all new and existing permanent monitoring wells for field and laboratory analysis. Natural Attenuation Indicator Parameters will be analyzed in order to demonstrate that biological degradation is a dominant physical process that is occurring in the shallow aquifer.
- Natural gamma logging of existing and newly installed deep monitoring wells will be performed in order to confirm the characterization of the lithology at Site 88. The geophysical logs will be compared with boring log descriptions completed by Baker Environmental in the Focused RI (1998) and the new boring logs by CH2M HILL on the new wells to provide an understanding of site lithology.
- Aquifer testing will be conducted in the intermediate and deep aquifers. Each test will comprise of a monitored 72-hour pumping test followed by a recovery test. Existing monitoring wells will be used to monitor drawdown during the tests.

1.2 Work Plan Structure

The structure of the Work Plan was developed in accordance with the CERCLA Work Plan guidelines (EPA 1988). A brief summary of the contents of each section of the Work Plan is provided below.

Section 1: Introduction – This section provides a brief discussion of the IRP process, the Work Plan objectives and scope of work, and the general organization of the Work Plan.

Section 2: Site Background and Environmental Setting – This section provides background information about Site 88 as well as previous investigations. This section also provides a description of the physical characteristics of the area, including demographics, meteorology, topography and drainage features, and geology.

Section 3: Initial Evaluation – This section describes the site being investigated under this RI, and includes a summary of the findings of previous site investigations, a site history, a description of the physical setting, a preliminary conceptual site model, and conclusions.

Section 4: Work Plan Rationale and Investigation Approach – This section describes the process by which this work plan was developed, defines the RI objectives and data quality objectives, and outlines the design of the RI field investigation.

Section 5: Site Evaluation Tasks – This section provides information on the tasks to be performed for the evaluation of the site characterization.

Section 6: Project Management and Schedule – This section provides information on the project management and organization as well as information on the schedule of investigations and deliverables, records maintenance and documentation, and quality control.

Section 7: References – This section provides a list of references used during the preparation of the RI Work Plan.

2 Site Background and Environmental Setting

This section of the Work Plan provides an overview of the physical characteristics of MCB Camp Lejeune, including information on demographics, climate, topography and drainage, geology, soil types, surface water features, hydrogeology, and potable water supplies.

2.1 Background

The Base is located on 236 square miles of land in Onslow County, North Carolina, adjacent to the southern side of the City of Jacksonville. Jacksonville is the largest city near the base and contains approximately half of the county's total population. Since 1990, much of the MCB Camp Lejeune complex has been part of Jacksonville. The areas adjacent to the base are generally rural.

The facility covers approximately 236 square miles. The MCB is bisected by the New River which flows into the Atlantic Ocean in a southeasterly direction. The base is bordered by the Atlantic Ocean to the east U.S. Route 17 to the west, and State Route 24 to the north.

Figure 2-1 shows the location of MCB Camp Lejeune. Site 88 is located in the Hadnot Point area of MCB Camp Lejeune. The site is referred to as Building 25, the Base Dry Cleaners. **Figure 2-2** shows the location of Site 88. **Figure 2-3** is the site plan.

2.2 Environmental Setting

2.2.1 Meteorology, Topography, and Drainage

The MCB Camp Lejeune area climate is characterized by mild winters and hot humid summers. Winters are usually short and mild with occasional and short duration cold periods. Summers are long, hot and humid. Average annual net precipitation is approximately 50 inches. Ambient air temperatures generally range from 33 to 53 degrees Fahrenheit (°F) in the winter months, and 71°F to 88°F during the summer months. Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (Water and Air Research, 1983).

The topography across the base and in the general vicinity displays very low relief. Across the base, surface elevations range from sea level to approximately 70 feet above mean sea level (msl). Most of the base has an elevation range of 20 to 40 feet above msl. MCB Camp Lejeune is bisected by the New River and its tributaries. The land at MCB generally slopes to the west toward the New River with a grade of about 0.5%. The relief between stream and interstream areas typically ranges from 20 to 30 feet. Site 88 is located within an interstream area and has little topographic relief, however, a slight rise does occur in the northwest of the site in the vicinity of the water tower. The surficial soils at Site 88 are classified as Baymeade-Urban land complex. These soils are described by the Soil Conservation Service (SCS) as having rapid drainage and slow runoff (USDA, 1992).

2.2.2 Geology

The regional stratigraphic framework of the Lower Coastal Plain in North Carolina is shown in **Figure 2-4**. The Surficial Aquifer, Castle Hayne confining unit, and the Castle Hayne Aquifer have all been described at MCB Camp Lejeune (Cardinell, et al., 1993). According to Cardinell, et al. (1993), three of the upper Tertiary Formations (Yorktown, Eastover, and Pungo River) shown on **Figure 2-4** are not found at MCB Camp Lejeune. Based upon Baker's findings, the Lower Miocene Belgrade Formation (Fm.) is also absent at Site 88. Cardinell et al. (1993) postulated that the New River may have eroded the Belgrade Fm. locally at MCB Camp Lejeune.

The uppermost undifferentiated formation of Quaternary age sediments consists of mostly fine sand with a lesser amount of silt. Thin discontinuous layers of silt and clay are found within the undifferentiated formation, including a silty unit ranging in thickness from 4 to 10 feet. However, this unit was not identified at 88-MW08IW on the western periphery of the site. The undifferentiated formation overlies the Oligocene Age River Bend Fm., which is encountered at elevations of -10 to -30 ft msl (40 to 60 ft bgs) at Site 88. This contact is indicated by a significant increase in formation density, although the boring logs from the Baker RI report (1998) suggest that the general lithologic character remains similar.

Within the River Bend Fm. sediments, sand is dominant with minor amounts of silt and shell fragments. The River Bend Fm. overlies the Eocene Castle Hayne Fm., although the maximum depth of investigation at Site 88 has thus far been limited to approximately 100 ft bgs, without encountering sediments of the Castle Hayne Fm.

The locations of three geologic cross-sections are shown on **Figure 2-5**. The following paragraphs describe these cross-sections.

Cross-section A-A' (**Figure 2-6**) trends north-south and passes through Building 25. The section includes the stratigraphic sequence of the undifferentiated and River Bend Formations described above.

At the north end of the A-A' section, the lithology alternates between sand and silt. The southern end of the section (in the vicinity of 88-MW04DW) contains mostly fine sand with the silt layer thinning. A continuous silt and clay layer, approximately 5 to 10 feet thick, was encountered at elevations of 10 to 14 ft msl (depths of 13 to 18 ft bgs) throughout the A-A' section. In the middle portion of the section (near 88-MW02DW), a thin fossil layer was described at -62 to -60 ft msl (roughly 88 to 90 ft bgs). The fossil layer is an identifying characteristic of the River Bend Formation (Cardinell, 1993).

Cross-section B-B' (**Figure 2-7**) trends west-east and passes just to the south of Building 25. Moving further west, the level of detail recorded on the Baker boring logs appears to decrease, resulting in the apparent presence of a large homogeneous sandy unit, and no clear distinction between the undifferentiated formation and the River Bend Fm. In the middle of the section, the log from 88-MW06IW shows a thin clay layer, extending from 8 to 10 ft msl (approximately 15 to 17 ft bgs). Three wells shown in this figure (88-MW06IW, 88-MW08, and 88-MW08IW) could not be located during the July 2002 field event and are presumed destroyed.

Cross-section A-C' (**Figure 2-8**) trends north-south and passes through Building 25, including two wells (88-MW05DW and 88-MW02DW) used in the previous cross sections. This section shows a continuous silt and clay layer, approximately 4 to 10 feet thick, which was encountered at elevations of 9 to 11 ft msl (depths of 14 to 18 ft bgs).

2.2.3 Site Hydrogeology

Figure 2-4 provides the hydrostratigraphic framework for the North Carolina Coastal Plain. As previously mentioned, several of the upper Tertiary Formations present in the regional framework, i.e. the Yorktown, Eastover, Pungo River, and Belgrade Formations, are absent at Site 88. The current site investigation activities have been limited to the surficial aquifer, which occurs within the Undifferentiated Fm., and the upper Castle Hayne aquifer which occurs within the River Bend Fm.

During the July 2002 well gauging event, the upper surface of the unconfined surficial aquifer at Site 88 was found to occur at an elevation of 8.9 to 19.2 ft msl. The semi-continuous silty unit of the Undifferentiated Fm. provides local confinement of the Castle Hayne aquifer (see **Figures 2-6** through **2-8**). During the July 2002 well gauging event (**Table 2-1**), the static water level elevation within the upper Castle Hayne aquifer was found to range from 7.7 to 8.9 ft msl (above the base of the silty confining unit). Potentiometric surface maps of the shallow, intermediate, and deep wells are shown in **Figures 2-9** through **2-11**.

The silty unit serves to inhibit downward groundwater movement and has also been observed to impede the vertical migration of DNAPL. Laboratory testing of samples collected from this unit, in the vicinity of 88-MW02, yielded vertical hydraulic conductivity values of 1.3×10^{-4} feet per day (ft/day) (**Table 2-2**). However, this unit varies in thickness across the study area, and according to Baker's boring logs (1998) does not appear to be present to the west of 88-MW06. Based on the Baker boring logs (1998), the Surficial and Castle Hayne aquifers may be in direct hydraulic communication in the western portion of the site.

2.2.4 Surface Water Hydrology

Natural surface drainage is poor at Site 88. Storm runoff is collected by storm sewers, but water pools in grassy areas because of the topography. There are no surface water features located on Site 88. Beaverdam Creek is the closest surface water, located roughly 1,500 ft to the northeast, and the New River is approximately 3000 ft to the west.

Tables

Table 2-1
Well Gauging Summary, July 22, 2002
OU 15, Site 88
MCB Camp Lejeune, NC

Well ID	Aquifer	Depth to Water (ft)	Depth to Product (ft)	Total Depth of Well (ft)	Product thickness	Well Elevation (ft msl)	GW Elevation
88-MW01	Shallow	6.88	--	21.41	0.00	26.07	19.19
88-MW02	Shallow	7.40	--	22.83	0.00	25.11	17.71
88-MW02DW	Deep	17.48	--	97.31	0.00	25.10	7.62
88-MW02IW	Intermediate	17.46	--	48.81	0.00	25.14	7.68
88-MW03	Shallow	6.89	--	14.92	0.00	25.38	18.49
88-MW03DW	Deep	17.08	--	84.12	0.00	25.32	8.24
88-MW03IW	Intermediate	16.75	--	48.69	0.00	25.62	8.87
88-MW04	Shallow	15.62	--	24.08	0.00	24.54	8.92
88-MW04DW	Deep	15.85	--	85.15	0.00	24.61	8.76
88-MW04IW	Intermediate	15.84	--	48.04	0.00	24.60	8.76
88-MW05	Shallow	7.52	--	21.77	0.00	23.97	16.45
88-MW05DW	Deep	15.85	--	80.60	0.00	24.33	8.48
88-MW05IW	Intermediate	15.85	--	48.52	0.00	24.33	8.48
88-MW06	Shallow	14.23	--	22.50	0.00	23.13	8.90
88-MW07	Shallow	10.86	--	22.05	0.00	23.37	12.51
88-MW07IW	Intermediate	15.39	--	50.05	0.00	23.38	7.99
88-MW09	Shallow	10.27	--	20.81	0.00	21.83	11.56
88-MW09IW	Intermediate	13.32	--	49.25	0.00	21.74	8.42
88-MW10IW	Intermediate	17.04	--	38.32	0.00	25.5 *	8.46*
EX01	Shallow	7.17	--	19.97	0.00	NS	NS
EX02	Shallow	7.06	--	21.07	0.00	NS	NS
EX04	Shallow	6.90	19.49	21.15	1.66	NS	NS
EX04R	Shallow	6.75	19.18	19.72	0.54	NS	NS
EX05	Shallow	6.44	--	21.53	0.00	NS	NS
EX06	Shallow	6.71	--	20.11	0.00	NS	NS
HC02	Shallow	7.13	--	19.98	0.00	NS	NS
IN01	Shallow	6.99	--	22.71	0.00	NS	NS
IN02	Shallow	6.75	--	19.04	0.00	NS	NS
IN03	Shallow	6.71	--	19.28	0.00	NS	NS
IW01	Shallow	6.50	--	17.34	0.00	NS	NS
RABITTIW1	Intermediate	15.31	--	47.25	0.00	NS	NS
RABITTIW2	Intermediate	15.25	--	47.03	0.00	NS	NS
RABITTIW3	Intermediate	15.20	--	47.10	0.00	NS	NS
RABITTMW1	Intermediate	15.28	--	46.79	0.00	NS	NS
RABITTMW2	Intermediate	15.25	--	46.68	0.00	NS	NS
RABITTMW3	Intermediate	15.22	--	46.72	0.00	NS	NS
RABITTMW4	Intermediate	15.06	--	46.85	0.00	NS	NS
RABITTMW5	Intermediate	15.25	--	47.05	0.00	NS	NS
RABITTMW6	Intermediate	15.11	--	46.78	0.00	NS	NS
RABITTMW7	Intermediate	14.88	--	46.84	0.00	NS	NS
RABITTMW8	Intermediate	14.95	--	46.28	0.00	NS	NS
RABITTMW9	Intermediate	15.00	--	46.97	0.00	NS	NS
RW01	Shallow	6.87	19.27	19.68	0.41	NS	NS
RW02	Shallow	6.68	19.54	19.60	0.06	NS	NS
RW04	Shallow	6.94	22.31	22.32	0.01	NS	NS

* - Estimated
NS - Not surveyed

Table 2-2
Summary of Laboratory Permeability Testing
OU 15, Site 88
MCB Camp Lejeune, NC

Well ID	Depth (ft. bgs)	Bulk Density (lbs/ft^3)	Vertical Permeability (ft./day)	Lithology
88-MW02	2-4	73.1	1.76	Silty Sand
88-MW04IW	16-18	88	1.28 x 10-4	Clay
88-SB04	20-22	85.85	1.79 x 10-4	Clay

Figures

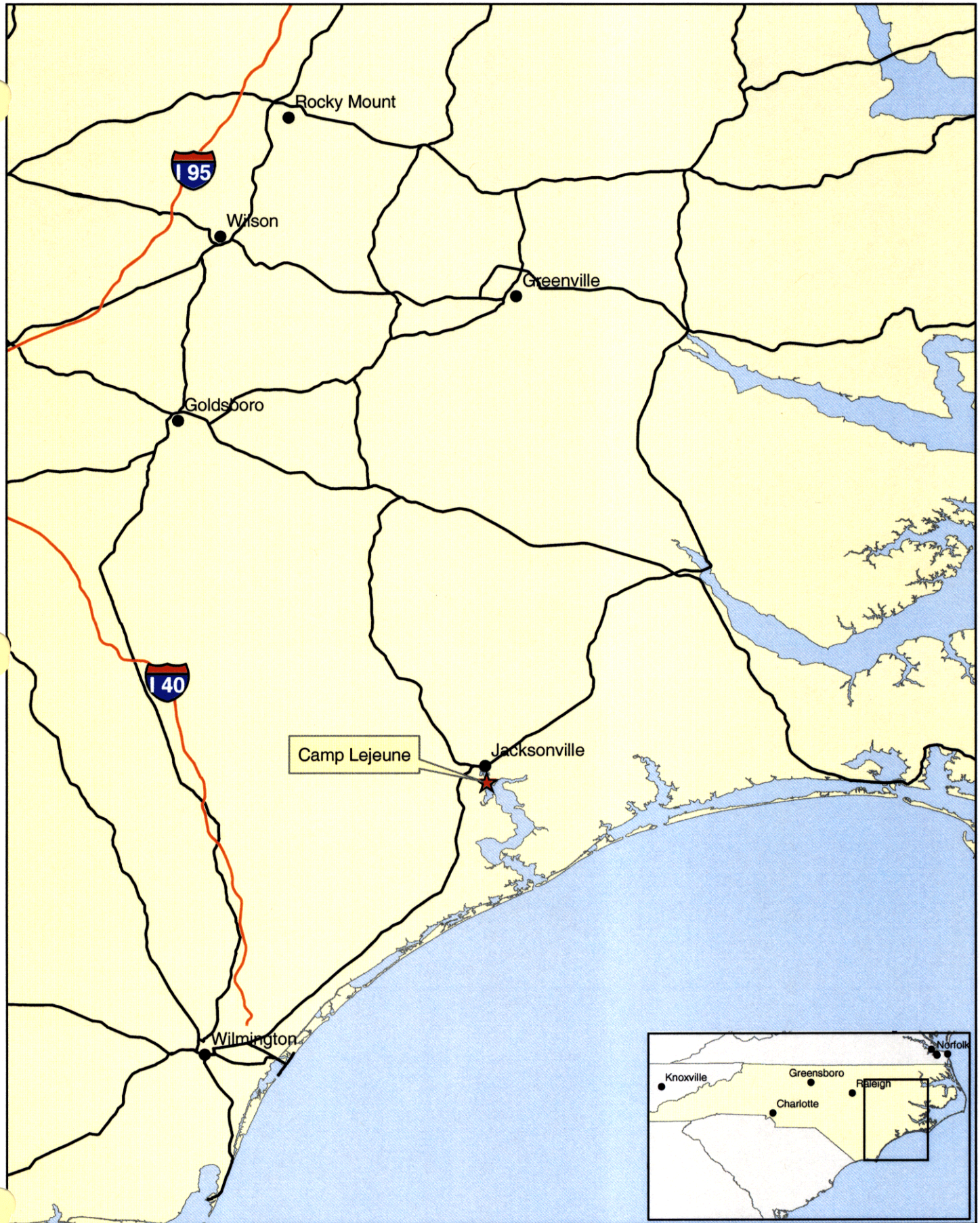
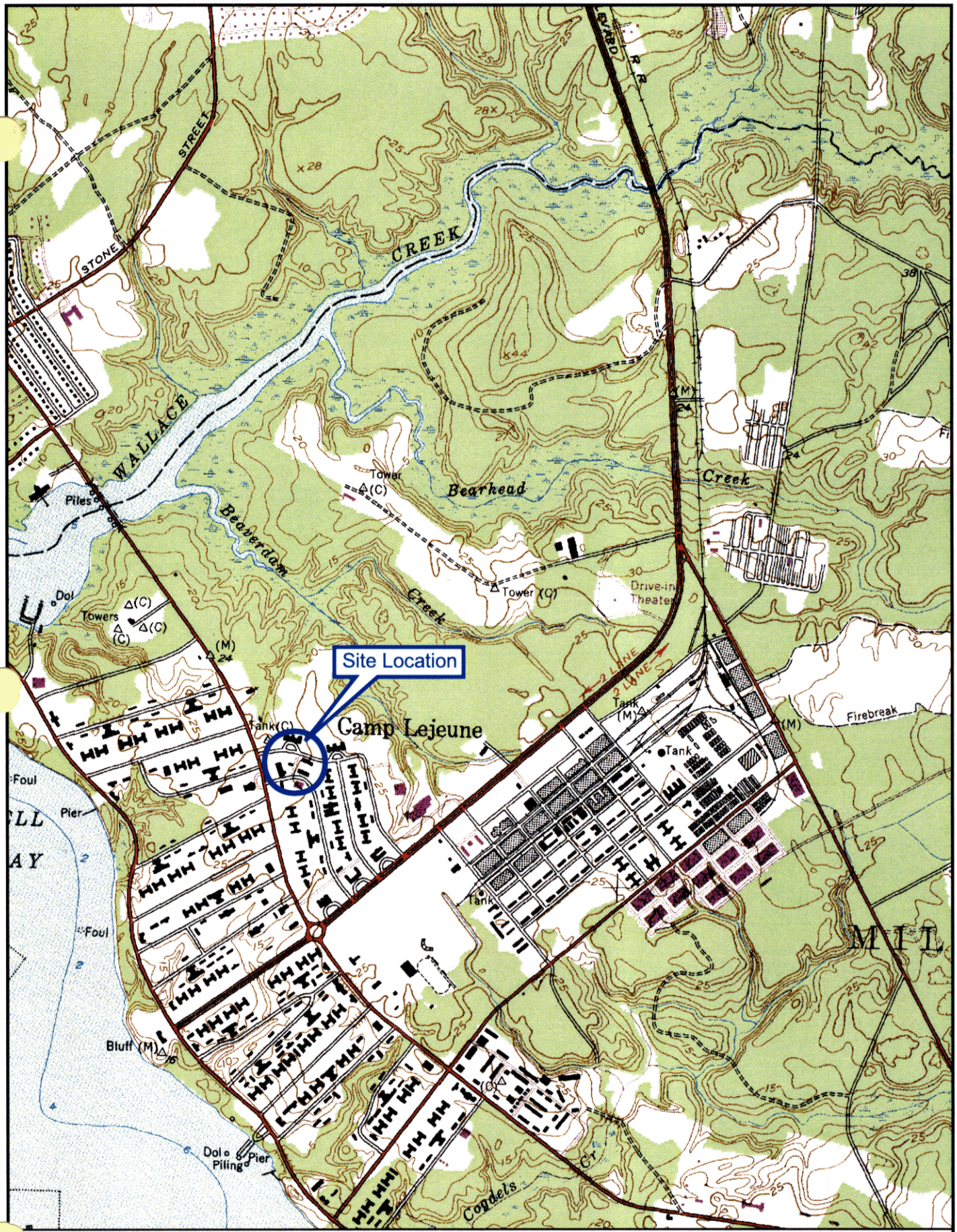


Figure 2-1
Base Location Map
MCB Camp Lejeune
CH2MHILL

File Path: \\Boomer\G\projects2\CampLejeune\mxd\Location.mxd, Date: October 09, 2002.



USGS 7.5 Minute Quadrangle
Camp Lejeune, NC
Contour Interval 5 feet

N

0 1000 2000 3000 4000 Feet

Figure 2-2
Site Location Map
O.U. 15, Site 88, MCB Camp Lejeune

CH2MHILL

File Path: G:\projects2\CampLejeune\mxd\figure1-1.apr 09/13/02

CH2MHILL

Figure 2-3
Site Plan
Operable Unit 15, Site 88
MCB Camp Lejeune, North Carolina

Figure 2-4

Hydrostratigraphic units of North Carolina Coastal Plain.

Geologic Units			Hydrogeologic Units
System	**Series**	**Formation**	**Aquifer and Confining Unit**
Quaternary	Holocene/Pleistocene	Undifferentiated	Surficial aquifer
Tertiary	Pliocene	Yorktown[1]	Yorktown confining unit
			Yorktown Aquifer
	Miocene	Eastover[1]	Pungo River confining unit
		Pungo River[1]	
			Pungo River Aquifer
		Belgrade[2]	Castle Hayne confining unit
	Oligocene	River Bend	Castle Hayne Aquifer
	Eocene	Castle Hayne	
			Beaufort confining unit[3]
	Paleocene	Beaufort	Beaufort Aquifer
			Peedee confining unit
Cretaceous	Upper Cretaceous	Peedee	
			Peedee Aquifer
		Black Creek and Middendorf	Black Creek confining unit
			Black Creek Aquifer
		Cape Fear	Upper Cape Fear confining unit
			Upper Cape Fear Aquifer
			Lower Cape Fear confining unit
			Lower Cape Fear Aquifer
	Lower Cretaceous	Unnamed deposits[1]	Lower Cretaceous confining unit
			Lower Cretaceous Aquifer[1]
Pre-Cretaceous basement rocks			

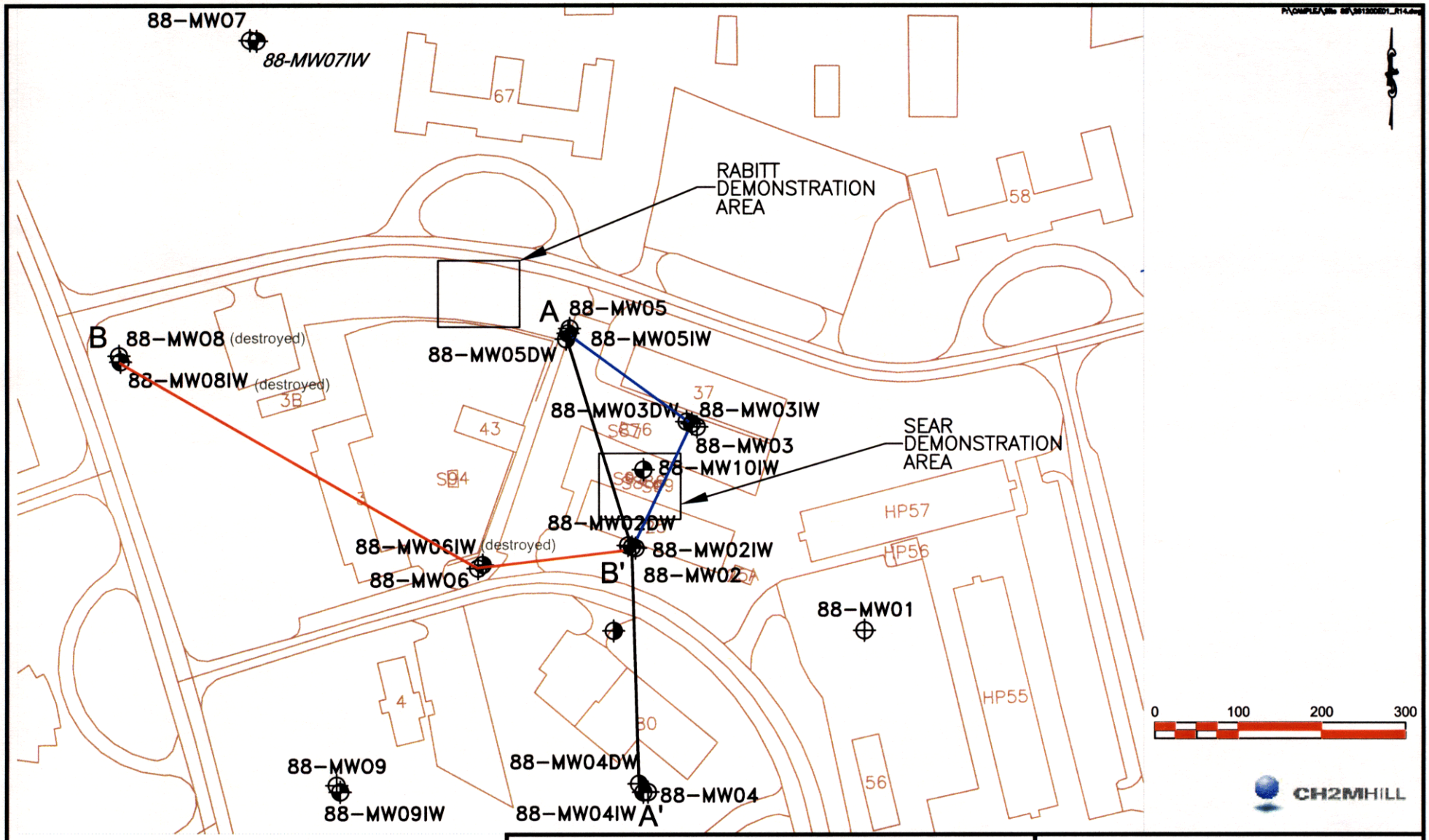
Notes:

(1) Geologic and hydrologic units probably not present beneath MCB Camp Lejeune.

(2) Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.

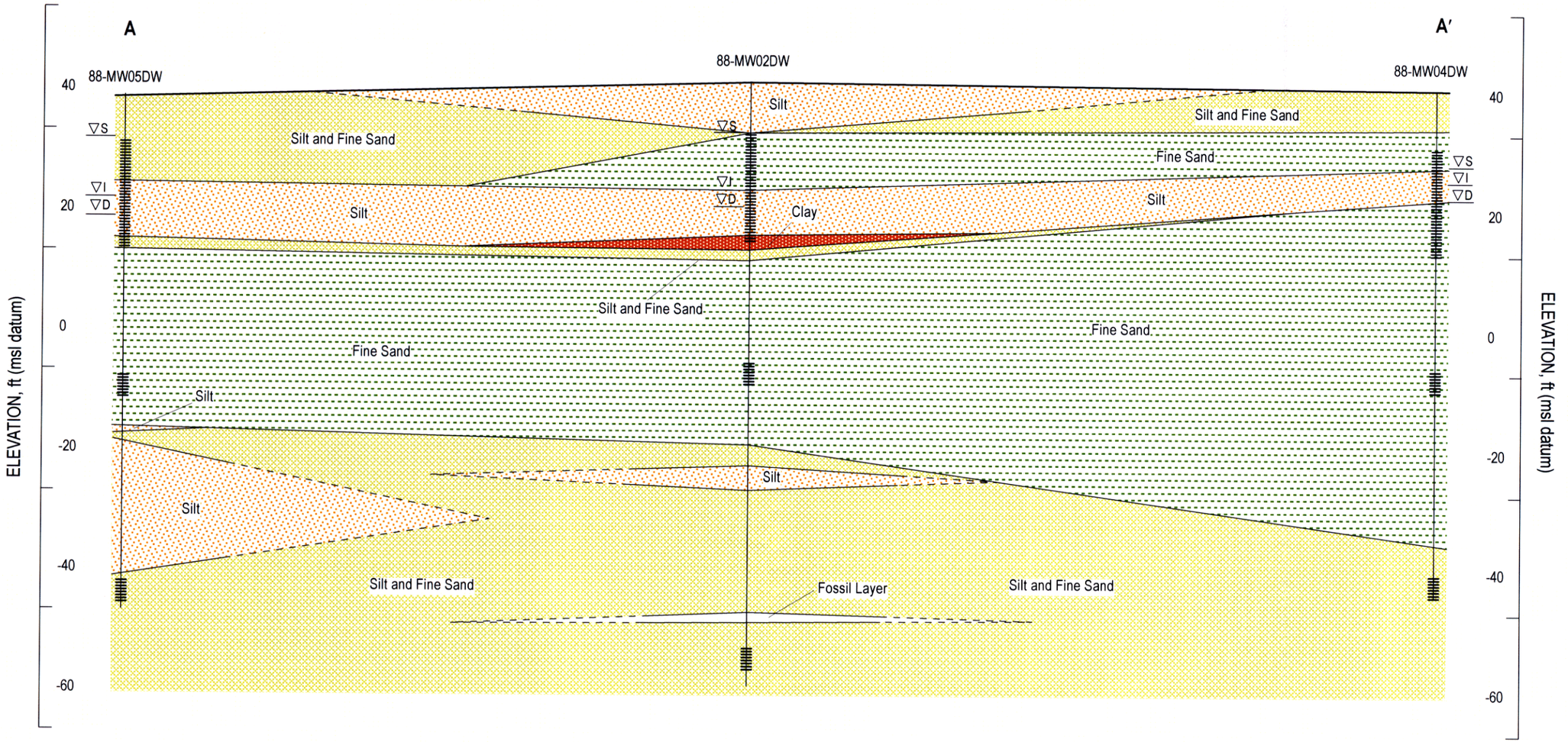
(3) Estimated to be confined to deposits of Paleocene age in the study area.

Source: Harned et al., 1989.

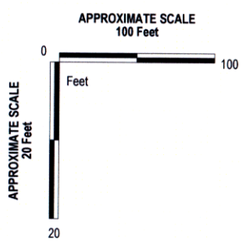


SOURCE: MCB, CAMP LEJEUNE MARCH 2000

FIGURE 2-5
PERMANENT WELL LOCATION MAP
OPERABLE UNIT No. 15 – SITE 88
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Notes:
The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions applies only to the specific locations and dates indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.



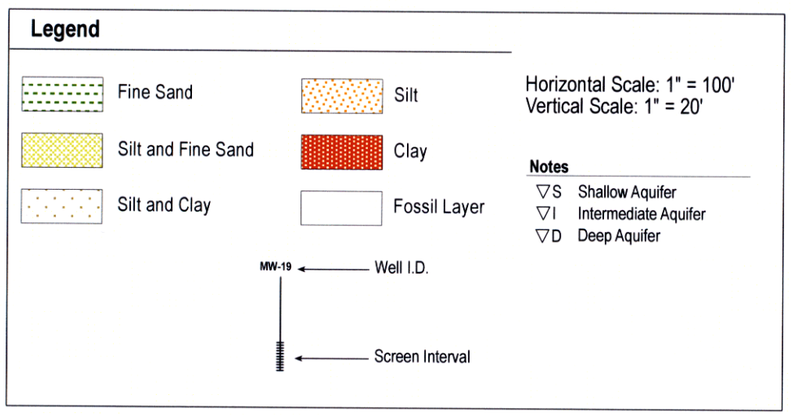
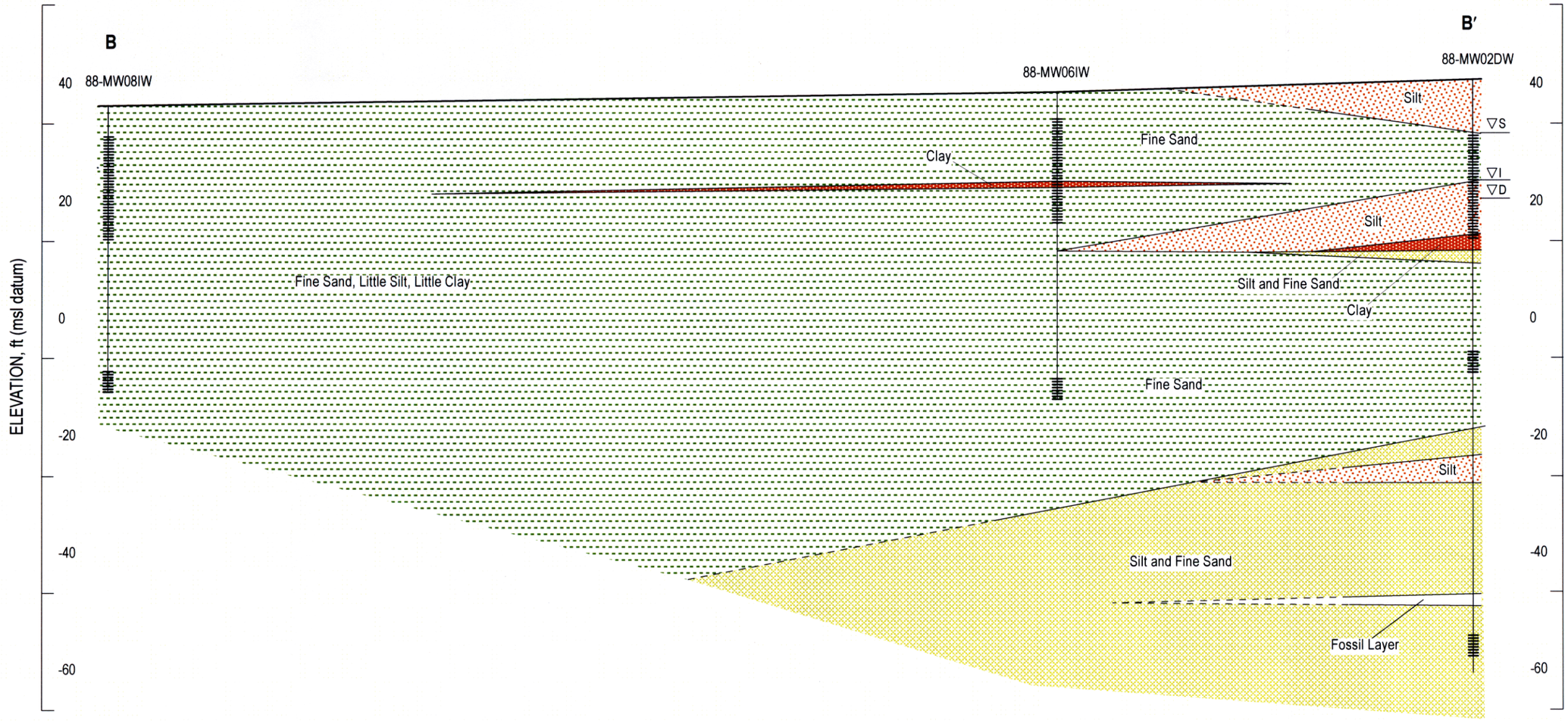
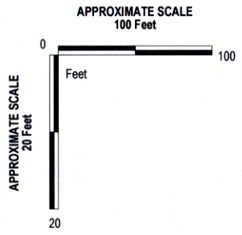


Figure 2-6
MCB Camp Lejeune Site 88 Cross-Section A-A'
Camp Lejeune



Notes:
The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions applies only to the specific locations and dates indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.



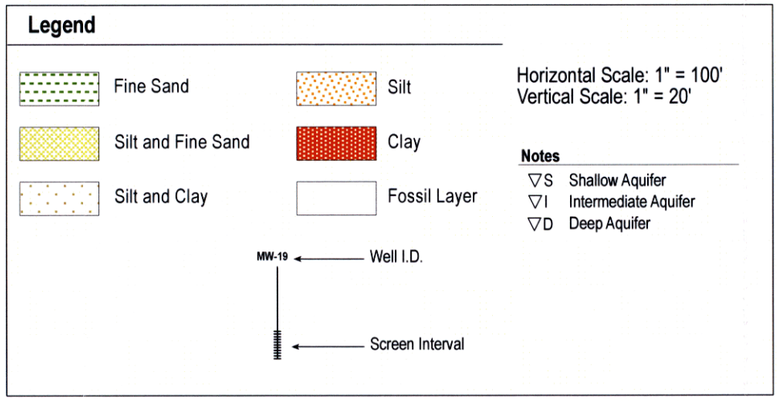


Figure 2-7
MCB Camp Lejeune Site 88 Cross-Section B-B′
Camp Lejeune

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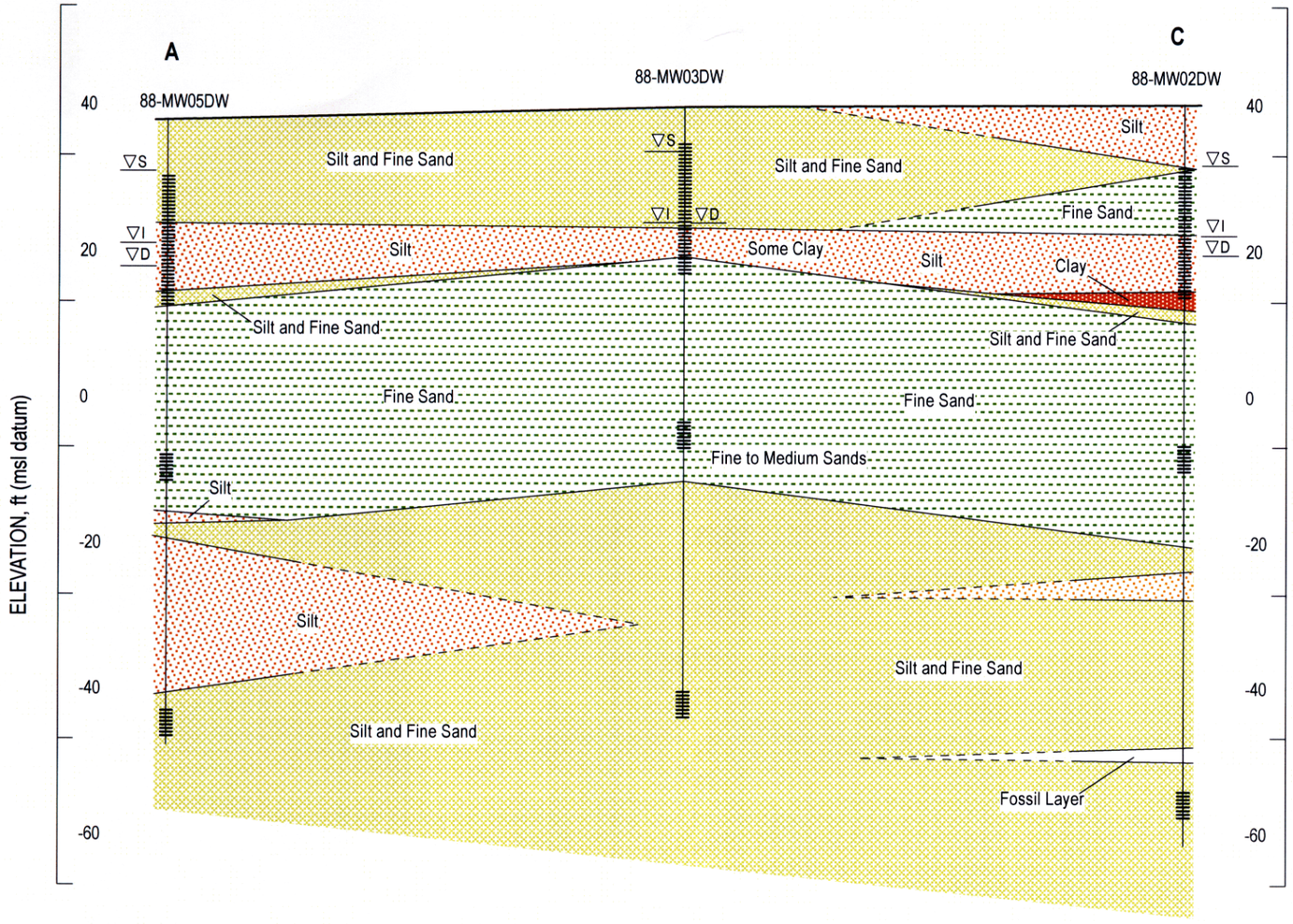
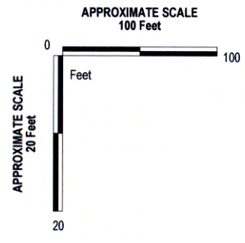


Notes:
The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions applies only to the specific locations and dates indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.



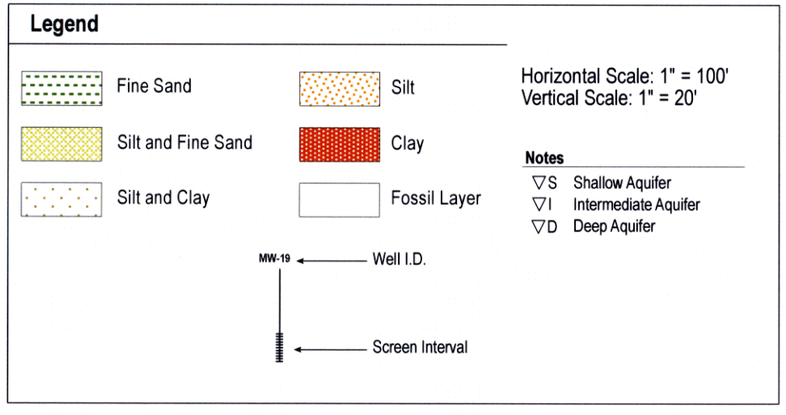


Figure 2-8
MCB Camp Lejeune Site 88 Cross-Section A-C
Camp Lejeune

88-MW07
(12.51)

88-MW08
(NOT FOUND)

88-MW05
(16.45)

88-MW03
(18.49)

88-MW06
(8.90)

88-MW02
(17.71)

88-MW01
(19.19)

88-MW09
(11.56)

88-MW04
(8.92)

14
12
10
8
16
18
20
10

0 100' 200' 300

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LEGEND

- ⊕ – SHALLOW MONITORING WELL
- ——— – POTENTIOMETRIC SURFACE CONTOUR – 07/22/02 (DASHED WHERE INFERRED)
- ◀——— DIRECTION OF GW FLOW

FIGURE 2-9
POTENTIOMETRIC SURFACE (SHALLOW WELLS)
OPERABLE UNIT No. 15 – SITE 88
MARINE CORPS BASE, CAMP LEJEUNE

P:\EBL\Navy Clean\CTO 250\Site 88\CADD\Intermediate_wells.dwg

88-MW07IW
(7.99)

88-MW08IW
(NOT FOUND)

88-MW05IW
(8.48)

88-MW03IW
(8.87)

88-MW10IW
(8.46)

88-MW06IW
(NOT FOUND)

88-MW02IW
(7.68)

88-MW09IW
(8.42)

88-MW04IW
(8.76)

7.9
8.1
8.3
8.5
8.7
8.9

0 100 200 300
1"=100'

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LEGEND

- INTERMEDIATE MONITORING WELL
- POTENTIOMETRIC SURFACE CONTOUR (DASHED WHERE INFERRED)

SOURCE: MCB, CAMP LEJEUNE MARCH 2000

FIGURE 2-10
POTENTIOMETRIC SURFACE (INTERMEDIATE WELLS)
OPERABLE UNIT No. 15 – SITE 88
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

P:\EBL\Navy Clean\CTO 250\Site 88\CADD\Deep_wells.dv

8.7
8.3
7.9
7.5
8.9

88-MW05DW
(8.48)

88-MW03DW
(8.24)

88-MW02DW
(7.62)

88-MW04DW
(8.76)

0 100' 200' 300

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LEGEND

- DEEP MONITORING WELL
- POTENTIOMETRIC SURFACE CONTOUR – 07/22/02 (DASHED WHERE INFERRED)
- DIRECTION OF GW FLOW

SOURCE: MCB, CAMP LEJEUNE MARCH 2000

FIGURE 2-11
POTENTIOMETRIC SURFACE (DEEP WELLS)
OPERABLE UNIT No. 15 – SITE 88
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3 Site Description and Previous Investigations

3.1 Site History

3.1.1 Sources of Historical Information on Site 88 Operations

In preparing this document, CH2MHILL has relied upon information presented in the 1998 Focused Remedial Investigation Report, produced by Baker Environmental that documents their 1997 investigation activities. In addition to the Baker Focused RI report, information was found in the surfactant enhanced aquifer remediation (SEAR) and reductive anaerobic in situ treatment technology (RABITT) pilot test reports. No additional historical research was conducted in support of this report.

3.1.2 Summary of Operations and Chemicals used at Site 88

Building 25 has reportedly been utilized as a dry cleaning facility since the 1940's. Five underground storage tanks (USTs) were installed on the north side of the building to store dry cleaning fluids (**Table 3-1**). Initially, Varsol™ was used in dry cleaning operations at Building 25, although the use of Varsol™ was discontinued during the 1970's due to concerns about its flammability.

TABLE 3-1
Summary of Product Usage and Waste Disposal
OU No. 15, Site 88, MCB Camp Lejeune, NC

Product	Dates Used	Storage	Disposal
Varsol™	1940's-1970's	Underground Storage Tanks	N/A
PCE	1970's- March, 1995	Above Ground Storage Tanks	Floor Drains
PCE	March, 1995-Present	Self-contained dry cleaning units	Off site

Varsol™ was replaced by tetrachloroethene (synonyms: tetrachloroethylene, perchloroethene, perchloroethylene, perc, and PCE). The PCE was stored in one 150-gallon above ground storage tank (AST) adjacent to the north wall of Building 25 in the same vicinity as the USTs. PCE was reportedly stored in the AST from the 1970's until the mid-1980's. During this time, facility employees have reported that spent PCE was disposed of in floor drains. In March 1995, self-contained dry cleaning machines were installed in Building 25, eliminating the need for bulk storage of PCE, and the USTs and AST were removed. There are currently two self-contained PCE dry cleaning units in operation at the site.

3.2 Historic Investigations and Pilot Studies

Baker conducted a RI in 1997. This work included: installation of temporary and permanent monitoring wells, groundwater sample collection, groundwater elevation measurements, on-site laboratory analysis, fixed-based laboratory analysis, and in-situ aquifer testing (slug tests) to evaluate hydraulic conductivity. In addition to the Baker studies, two pilot test were conducted at Site 88. The first was for SEAR was begun in 1999. The second pilot test, conducted in 2001, used RABITT.

3.2.1 Focused RI – Phase I (April 1997)

A total of 38 temporary monitoring wells were installed during Baker's November 1996 Phase I RI. Of the wells installed during this phase of investigation, 24 were shallow wells (15 to 20 ft bgs) and 14 were intermediate depth wells (approximately 50 ft bgs). These wells were used to characterize the nature and extent of contamination as well as provide information used to determine the placement of permanent wells. Samples collected from the temporary monitoring wells were analyzed for VOCs in an on-site laboratory. After the investigation was completed, all temporary wells were abandoned.

3.2.2 Focused RI – Phase II (April/May 1997)

A total of 21 permanent groundwater monitoring wells were installed during Baker's Phase II RI. Nine shallow wells were screened at the top of the surficial aquifer, bracketing the water table (15 to 25 ft bgs). Eight intermediate depth wells (39 to 50 ft bgs; defined by the "IW" suffix in the well identification) were screened at the top of the Castle Hayne aquifer and four deep wells (85 to 97 ft bgs; defined by the "DW" suffix in the well identification) were installed. **Table 3-2** presents well construction details for the permanent monitoring wells. The locations of these wells are shown in **Figure 2-5**.

Samples collected from the permanent monitoring wells were shipped to a fixed-base laboratory for analysis of TCL VOCs, engineering parameters, and NAIPs.

Slug tests were used to characterize the hydraulic conductivity of the Surficial and upper Castle Hayne Aquifers. Rising and falling head tests were conducted in the intermediate and deep permanent monitoring wells, and rising head tests were conducted on the shallow monitoring wells.

3.2.3 Pilot Testing

Two remedial technology pilot tests have been conducted at Site 88 since the completion of the Focused RI.

Surfactant-Enhanced Aquifer Remediation (SEAR)

In 1999, Duke Engineering and Services in cooperation with Baker Environmental, Inc., completed a focused demonstration of SEAR at Site 88.

The demonstration involved the injection and subsequent extraction of a surfactant solution from a treatment cell measuring approximately 20 feet x 30 feet, located on the north side of Building 25 (USDoD, 2001). It was estimated that the treatment cell encompassed approximately 25% of the DNAPL zone at Site 88. **Figure 3-1** shows the location of the

treatment cell. The treatment cell was equipped with three injection wells (designated IN01 through IN03) and six extraction wells (designated EX01 through EX06) arranged in a 3 x 3 x 3 array with the injection wells in the center of the array. Hydraulic control wells (designated HC01 and HC02) were installed at each end of the injection wells. All wells were installed within the surficial aquifer, to a depth of approximately 20 feet below ground surface (bgs). **Table 3-3** presents a summary of the SEAR well construction details.

Continuous surfactant injection was performed for 143 days, beginning on March 15, 1999 and ending on August 30, 1999. The surfactant used was Alfoterra 145-4-PO Sulfate™. The injected surfactant solution contained 4% surfactant, 16% isopropyl alcohol (IPA), 0.16 to 0.19% Calcium chloride, with the remainder of the solution consisting of groundwater from the treatment cell. **Table 3-4** summarizes the mass of surfactant formulation chemicals injected.

TABLE 3-4
Summary of Surfactant Formulation Chemicals Injected
OU No. 15, Site 88, MCB Camp Lejeune, NC

Constituent	Mass Injected
Alfoterra 145-4-PO Sulfate™	9,718 lbs.[(a)]
Isopropyl alcohol	38,637 lbs.
Calcium chloride	1,806 lbs.

(a) This includes 1,806 lbs. of recovered surfactant that was re-injected during the latter 20 days of surfactant flooding

During the period from March 29 until August 19, 1999, 268,000 gallons of total fluids (consisting of a mixture of surfactant, DNAPL, and groundwater) were extracted from the treatment cell. Following extraction, 101,000 gallons were pretreated using pervaporation and ultrafiltration, the remaining volume was transported to the wastewater treatment plant located at Lot 203. The pervaporation was found to be 95% effective for the removal of PCE and 33 to 57% effective for the removal of Varsol™. A total of 76 gallons of PCE were removed during the SEAR demonstration. However, the majority of the DNAPL removed was a result of Aggressive Fluid Vapor Recovery events before the SEAR project started. A post-SEAR investigation estimated the volume of DNAPL remaining in the treatment cell to be approximately 29 gallons.

The low permeability of the basal silt provided challenges to this technology. The flushing of DNAPL from this and other low permeability units was unsuccessful. The remedial design was based on previous investigations where permeabilities were much higher. The high permeability contrast within surficial aquifer along with low absolute permeability of the basal silt rendered the surfactants ineffective in the basal silt.

Reductive Anaerobic In-Situ Treatment Technology (RABITT)

RABITT treatability testing was performed by Battelle Memorial Institute (BMI) in the northwestern portion of Site 88 during the spring and early summer of 2001. The stated goal of the study was to investigate if "microbially-catalyzed reductive dechlorination of chloroethenes could be stimulated in-situ."

A treatment cell consisting of a total of 12 intermediate-depth wells were installed to the west of 88-MW05. These wells were installed with screened intervals ranging from 45 to 48 ft bgs. Three of the wells were initially designated as injection wells (IW-1 through IW-3), with the remainder being designated as monitoring wells (MW-1 through MW-9). **Figure 3-2** illustrates the configuration of the RABITT well array. **Table 3-5** summarizes the RABITT well construction details. Two existing wells were also used during the RABITT study. Well 88-MW05IW was used to supply PCE-contaminated ground water for injection, and well 88-MW03IW was used for background sampling.

In preparation for the study, a sodium bromide tracer test was conducted to evaluate the direction of groundwater flow through the treatment cell. The initial test yielded unexpected results, suggesting that groundwater injected into IW-1 through IW-3 may be flowing to the northeast, away from the treatment cell. Consequently, the tracer test was re-configured to use MW-5, located centrally, to act as the injection well. The revised test indicated essentially radial groundwater flow from the injection well.

During the RABITT test, PCE-contaminated groundwater was pumped from 88-MW05IW, amended with electron donor solution (3,000 µM butyric acid and yeast extract), and then injected into MW-5. Groundwater samples were collected and analyzed over a period of 30 weeks.

The RABITT study concluded that native subsurface microbial populations were capable of sequentially reducing PCE to ethene. Also, BMI observed that PCE and TCE concentrations were reduced to below detectable levels in almost all wells after 14 weeks and remained depressed throughout the remainder of the demonstration. It was reported that the degradation of PCE and TCE occurred so rapidly that the injected PCE-contaminated groundwater was free of both PCE and TCE by the time it reached the first monitoring well only 5.4 feet away.

3.3 Preliminary Conceptual Site Model

A preliminary conceptual site model was developed for Site 88 under the SSI. The findings for both the preliminary human and ecological evaluations are summarized below. The model is summarized in **Figure 3-3.**

3.3.1 Preliminary Human Health Evaluation

Exposure Pathway Assessment

The exposure to contaminants associated with activities at Site 88 are affected by several factors:

- The site is still operational as the Base Dry Cleaners.
- The site is located in the developed Hadnot Point area of MCB Camp Lejeune
- Shallow groundwater is not used for potable water supply at the site. Groundwater migrates toward the west.

Shallow groundwater is unlikely to be used for water supply based on the availability of an alternate source of better yield.

Volatile Organic Compounds. VOCs are generally mobile in groundwater and tend to volatilize from surface soils. In 1997, Baker determined that the significance and extent soil contamination was minimal. The minimal data collected would be used to evaluate current conditions. The organic chemical concentration most likely has changed with time due to attenuation factors (degradation, dispersion, etc.) while inorganic chemical concentrations may not change significantly. Thus it is extremely beneficial to determine current concentrations by collecting at least some samples in previous sampling locations for cross comparison between data. This is in accordance with data quality evaluation guidance from EPA.. Elevated concentrations of chlorinated solvents and their degradation products were present in groundwater samples, suggesting a release to groundwater has occurred. The deeper aquifer is used as a potable water supply, and chlorinated solvents (in the non aqueous phase) with a high specific gravity may migrate downward in groundwater. Therefore, plume definition should include vertical and horizontal components.

Priority Pollutant Metals. Various metals were reported in the soils, but may be attributed to natural occurrences since they were present at concentrations below background levels.

As with samples collected from other sites at the Base, the shallow groundwater samples had elevated concentrations of metals that do not appear to be related to specific activities at the site. Suspended solids in groundwater samples can contribute to the elevated metal concentrations, and the concentration detected may be more representative of the Base-wide levels characteristic of acidic shallow groundwater. The base-wide background study currently being conducted by Baker should resolve the issue of whether or not these metal concentrations are above or in line with background.

Toxicity Assessment. Groundwater samples from several wells at Site 88 had concentrations that exceeded potential applicable or relevant and appropriate requirements (ARARs). The results of the July 2002 groundwater monitoring event reported in the SSI show that significant groundwater contamination still exists at Site 88. Acetone, benzene, chlorobenzene, chloroform, chloromethane, 1,1-dichloroethene (1,1-DCE), cis-1,2-DCE, trans-1,2-DCE, PCE, TCE, and vinyl chloride were all detected above their respective North Carolina Water Quality Standards (NCGWQS).

Risk Screening for Soils

In 1997, Baker determined that the significance and extent soil contamination was minimal. In the five years that have passed since the focused RI, site conditions have likely changed. The organic chemical concentration most likely has changed with time due to attenuation factors (degradation, dispersion, etc.) while inorganic chemical concentrations may not change significantly.. Soils need to be reevaluated in order to reestablish the findings of the focused RI. This area is a hub for utilities, and because of this soils will be continually disturbed when utility work is performed. These workers face a risk when working in this area until all soil contamination is removed, even though concentrations of VOCs in the soils are low.

Risk Screening for Groundwater

Shallow groundwater is not used on Base as a potable water supply; however, the aquifer could potentially be used in the future. Acetone, benzene, chlorobenzene, chloroform, chloromethane, 1,1-dichloroethene (1,1-DCE), cis-1,2-DCE, trans-1,2-DCE, PCE, TCE, and

vinyl chloride were all detected above their respective NCGWQS. Although no current, completed exposure pathway was identified, potential risks may occur if these contaminants migrate offsite or to the deeper aquifer. Additional information on the vertical and horizontal extent of the contamination is required to determine if additional action is required.

Metals in the unfiltered groundwater sample were elevated. The iron, manganese, and cyanide were detected above NCGWQS. These metals are not likely to be mobile, and their detections, which may be associated with suspended solids, appear to represent Base-wide conditions. The preferable method for determining the mobility of metals is through low flow sampling (EPA/540/S-95/504/ April 1996). If low flow sampling is not effective in lowering the turbidity of the sample, filtered groundwater samples need to be analyzed for metals (EPA/600/R-94/119 October 1994). A 5.0 μm filter would limit the amount of colloidal metals and dissolved species in the sample. Without low turbidity samples or filtered metals data, it cannot be said if the metals are mobile. The presence of VOCs in the groundwater often changes the eH/pH of the environment and the metals will speciate to more soluble forms as a result.

3.3.2 Preliminary Ecological Evaluation

No surface water features exist at Site 88, and the connection between the site and other surface water bodies has not been established. Groundwater concentration of several VOC compounds as well as metals were higher than surface water standards, but are not believed to discharge to surface water.

Tables

T: 2
Summary of Perma.. t Monitoring Well
Construction Details
OU 15, Site 88
MCB Camp Lejeune, NC

Well ID	Date Installed	Casing Diameter (in)	Elevation (feet above msl)		Boring Depth (feet bgs)	Well Depth (feet bgs)	Screen Intervals (feet above msl)		Sand Pack Interval (feet bgs)	Bentonite Interval (feet bgs)	Well Completion
			Top of PVC Casing	Ground Surface			Lower	Upper			
88-MW02DW	04/20/97	2.0	25.10	26.5	100.0	97.0	92.0	97.0	87.0 - 97.0	82.0 - 87.0	Flush Mount
88-MW03DW	04/30/97	2.0	25.32	25.890	85.0	85.0	80.0	85.0	75.0 - 85.0	70.0 - 75.0	Flush Mount
88-MW04DW	04/18/97	2.0	24.61	24.950	85.0	85.0	80.0	85.0	76.0 - 85.0	73.0 - 76.0	Flush Mount
88-MW05DW	04/22/97	2.0	24.33	24.740	87.0	85.0	80.0	85.0	75.0 - 85.0	70.0 - 75.0	Flush Mount
88-MW02IW	05/03/97	2.0	25.14	26.500	50.0	50.0	45.0	50.0	40.0 - 50.0	34.5 - 40.0	Flush Mount
88-MW03IW	05/01/97	2.0	25.62	25.890	50.5	50.0	45.0	50.0	40.0 - 50.0	35.0 - 40.0	Flush Mount
88-MW04IW	05/02/97	2.0	24.60	24.980	50.0	50.0	45.0	50.0	39.5 - 50.0	34.0 - 39.5	Flush Mount
88-MW05IW	05/03/97	2.0	24.33	24.700	50.0	49.2	45.0	50.0	40.0 - 50.0	35.0 - 40.0	Flush Mount
88-MW06IW	05/04/97	2.0	23.04	24.590	50.0	50.0	45.0	50.0	32.5 - 50.0	26.0 - 32.5	Flush Mount
88-MW07IW	05/05/97	2.0	23.38	23.600	50.0	50.0	45.0	50.0	40.0 - 50.0	35.0 - 40.0	Flush Mount
88-MW08IW	05/07/97	2.0	22.91	23.050	50.0	50.0	45.0	50.0	39.5 - 50.0	34.0 - 39.5	Flush Mount
88-MW09IW	05/05/97	2.0	21.74	22.000	50.0	49.3	45.0	50.0	40.0 - 50.0	34.0 - 40.0	Flush Mount
MW10IW		1/4" tube	25.5 *	25.8*	40.0	39.0	(12.9) - (6.4)	None	(6.1) - 13.34	8.2 - 6.1	Flush Mount
88-MW01	05/01/97	2.0	26.07	26.5	22.0	22.0	7.0	22.0	2.0 - 22.0	2.0 - 5.0	Flush Mount
88-MW02	05/02/97	2.0	25.11	26.6	23.0	23.0	8.0	23.0	6.0 - 23.0	3.5 - 6.0	Flush Mount
88-MW03	05/01/97	2.0	25.38	25.88	16.0	15.0	5.0	15.0	4.0 - 15.0	2.0 - 4.0	Flush Mount
88-MW04	05/02/97	2.0	24.54	23.00	25.0	25.0	10.0	25.0	8.0 - 25.0	5.0 - 8.0	Flush Mount
88-MW05	05/03/97	2.0	23.97	24.50	23.0	23.0	8.0	23.0	6.0 - 23.0	3.0 - 6.0	Flush Mount
88-MW06	05/04/97	2.0	23.13	24.60	23.0	23.0	8.0	23.0	6.0 - 23.0	3.0 - 6.0	Flush Mount
88-MW07	05/06/97	2.0	23.37	23.63	22.0	22.0	7.0	22.0	5.0 - 7.0	2.0 - 5.0	Flush Mount
88-MW08	05/07/97	2.0	22.98	23.21	20.0	20.0	5.0	20.0	4.0 - 20.0	2.0 - 4.0	Flush Mount
88-MW09	05/05/97	2.0	21.83	22.13	21.0	21.0	6.0	21.0	4.0 - 21.0	2.0 - 4.0	Flush Mount
EX01	NA	4.0	25.63	25.59	NA	20.0	6.1 - 10.6	None	12.8 - 5.6	16.8 - 12.8	Flush Mount
EX02	NA	4.0	25.56	25.66	NA	21.2	4.9 - 9.5	None	11.8 - 4.2	14.7 - 11.8	Flush Mount
EX03	NA	4.0	25.64	25.98	NA	19.9	6.5 - 11.0	None	12.9 - 6.0	15.9 - 12.9	Flush Mount
EX04	NA	4.0	25.65	25.59	NA	21.1	4.9 - 9.5	None	11.8 - 4.6	14.1 - 11.8	Flush Mount
EX04R	NA	4.0	25.65	25.59	NA	19.7	6.3 - 10.9	None	13.1 - 5.6	16.9 - 13.1	Flush Mount
EX05	NA	4.0	25.22	25.42	NA	21.8	4.1 - 8.7	None	11.2 - 4.4	13.9 - 11.2	Flush Mount
EX06	NA	4.0	25.45	25.73	NA	20.4	5.7 - 10.3	None	12.5 - 5.2	15.5 - 12.5	Flush Mount
HC01	NA	2.0	26.42	26.85	NA	22.7	4.5 - 9.1	5.9 - 15	11.9 - 4.9	13.9 - 11.9	Flush Mount
HC02	NA	2.0	25.87	26.17	NA	20.4	6.1 - 10.8	13.9 - 18.4	11.8 - 6.1	12.8 - 11.8	Flush Mount
IN01	NA	4.0	25.71	25.54	NA	22.6	3.5 - 8.0	14.0 - 18.0	10.1 - 3.0	12.1 - 10.1	Flush Mount
IN02	NA	4.0	25.27	25.52	NA	19.7	6.5 - 11.0	14.5 - 18.5	11.6 - 5.5	12.6 - 11.6	Flush Mount
IN03	NA	4.0	25.34	25.80	NA	20.0	6.4 - 10.9	14.4 - 18.4	11.9 - 5.8	12.9 - 11.9	Flush Mount
RW01	NA	4.0	25.49	25.24	NA	20.0	6.2 - 10.4	None	13.2 - 5.2	16.2 - 13.2	Flush Mount
RW02	NA	4.0	25.54	25.35	NA	20.0	6.4 - 10.9	None	13.4 - 5.4	16.4 - 13.4	Flush Mount
RW03	NA	2.0	26.49	26.84	NA	22.0	5.2 - 9.9	15.8 - 19.7	12.0 - 5.0	14.0 - 12.0	Flush Mount
RW04	NA	4.0	25.78	26.07	NA	23.4	3.3 - 7.8	13.7 - 18.2	11.2 - 4.1	13.2 - 11.2	Flush Mount
RW06	NA	2.0	26.46	26.86	NA	21.1	6.1 - 10.8	14.2 - 18.7	12.4 - 6.4	13.9 - 12.4	Flush Mount
IW01	NA	2.0	25.61	25.24	NA	18.5	6.9 - 11.4	None	17.7 - 6.2	20.7 - 17.7	Flush Mount
WP01AQT	NA	1/4" tube	25.6*	NA	NA	23.0	2.6 - 3.6	None	4.0 - 2.2	10.6 - 4.0	NA
WP02AQT	NA	2.0	25.6*	NA	NA	25.0	0.6 - 1.6	None	2.6 - 0.2	10.6 - 2.6	NA

Notes:

Highlighted wells were not found during the July 2002 monitoring event

PVC - Polyvinyl Chloride

msl - Mean sea level

bgs - Below ground surface

* - Estimated from nearby wells

Table 3-3
'SEAR' Well Construction Details
OU 15, Site 88
MCB Camp Lejeune, NC

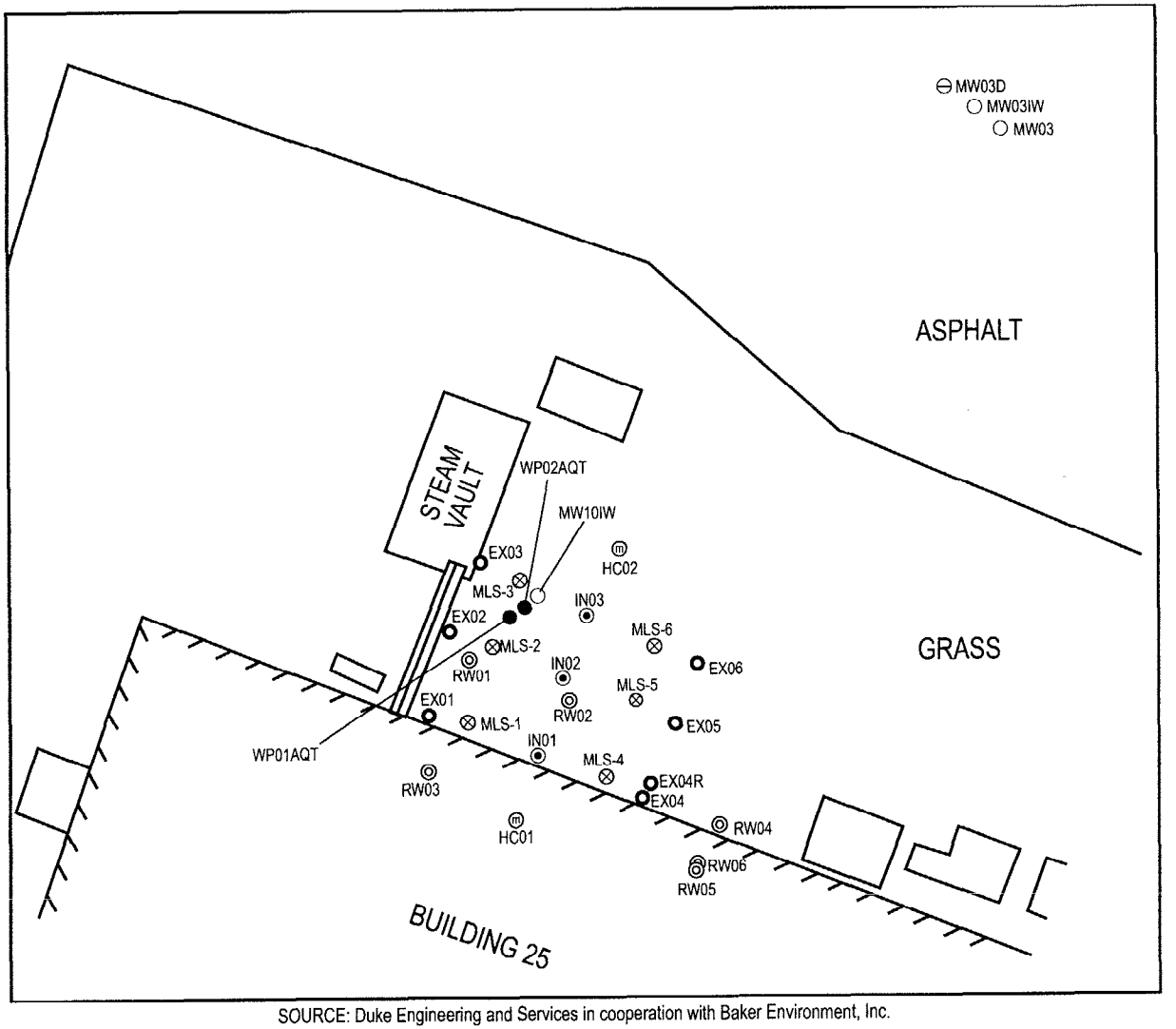
Well ID	Casing Diameter (in)	Elevation		Well Depth (ft bgs)	Screen Intervals (ft		Bentonite Seal Interval (ft msl)	Sand Pack Interval
		Top of Casing	Ground Surface		Lower	Upper		
EX01	4	25.63	25.59	19.96	6.1-10.6	None	16.8-12.8	12.8-5.6
EX02	4	25.56	25.66	21.20	5.9-9.5	None	14.7-11.8	11.8-4.2
EX03	4	25.64	25.98	19.94	6.5-11.0	None	15.9-12.9	12.9-6.0
EX04	4	25.65	25.59	21.09	4.9-9.5	None	14.0-11.8	11.8-4.6
EX04R	4	25.65	25.59	19.70	6.3-10.9	None	16.9-13.1	13.1-5.6
EX05	4	25.22	25.42	21.75	4.1-8.7	None	13.9-11.2	11.2-4.4
EX06	4	25.45	25.73	20.41	5.7-10.3	None	15.5-12.5	12.5-5.2
HC01	2	26.42	26.85	22.71	4.5-9.1	4.9-15	13.9-11.9	11.9-4.9
HC02	2	25.87	26.17	20.40	6.1-10.8	13.9-18.4	12.8-11.8	11.8-6.1
IN01	4	25.71	25.54	22.58	3.5-8	14.0-18.0	12.1-10.1	10.1-3.0
IN02	4	25.27	25.52	19.65	6.5-11	14.5-18.5	12.6-11.6	11.6-5.5
IN03	4	25.34	25.8	19.96	6.4-10.9	14.4-18.4	12.9-11.9	11.9-5.8
RW01	4	25.49	25.24	20.00	6.2-10.4	None	16.2-13.2	13.2-5.2
RW02	4	25.54	25.35	20.00	6.4-10.9	None	16.4-13.4	13.4-5.4
RW03	2	26.49	26.84	21.97	5.2-9.9	15.8-19.7	14.0-12.0	12.0-5.0
RW04	4	25.78	26.07	23.39	3.3-7.8	13.7-18.2	13.2-11.2	11.2-4.1
RW06	2	26.46	26.86	21.07	6.1-10.8	14.2-18.7	13.9-12.4	12.4-6.4
IW01	2	25.61	25.24	18.50	6.9-11.4	None	20.7-17.7	17.7-6.2
WP01AQT	0.25	25.6(1)	NA	23.00	2.6-3.6	None	10.6-4.0	4.0-2.2
WP02AQT	2	25.6(1)	NA	25.00	0.6-1.6	None	10.6-2.6	2.6-0.2

Note: (1)Estimated from nearby wells

Table 3-5
'RABITT' Well Construction Details
OU 15, Site 88
MCB Camp Lejeune, NC

Well ID	Diameter (in.)	Screened Interval (ft bgs)	Slot Size (in)	Material
IW01	0.75	45-48	0.01	Sch 80 PVC
IW02	0.75	45-48	0.01	Sch 80 PVC
IW03	0.75	45-48	0.01	Sch 80 PVC
MW-1	1	45.75-47.25	0.01	Sch 80 PVC
MW-2	1	45.75-47.25	0.01	Sch 80 PVC
MW-3	1	45.75-47.25	0.01	Sch 80 PVC
MW-4	1	45.75-47.25	0.01	Sch 80 PVC
MW-5	1	45.75-47.25	0.01	Sch 80 PVC
MW-6	1	45.75-47.25	0.01	Sch 80 PVC
MW-7	1	45.75-47.25	0.01	Sch 80 PVC
MW-8	1	45.75-47.25	0.01	Sch 80 PVC
MW-9	1	45.75-47.25	0.01	Sch 80 PVC

Figures



N

0 25 50

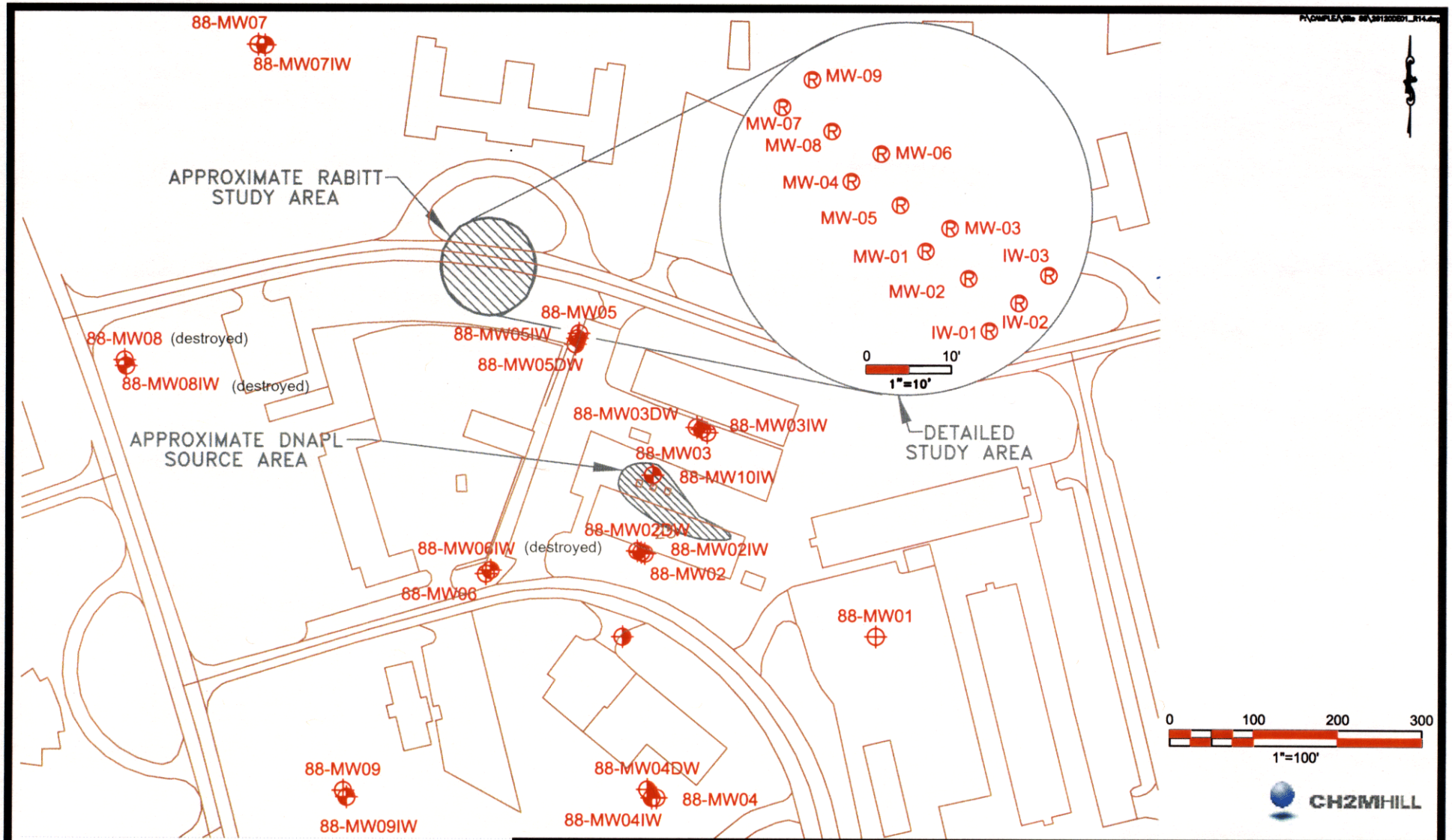
Scale in Feet

LEGEND

EX01	EXTRACTION WELL
IN01	INJECTION WELL
HC02	HYDRAULIC CONTROL WELL
MLS-3	MULTI-LEVEL SAMPLER
WP02A	AQUITARD MONITOR WELL POINT
MW03I	INTERMEDIATE MONITORING WELL
MW03	SHALLOW MONITORING WELL
MW03D	DEEP MONITORING WELL
RW01	RECOVERY WELL

SOURCE: Duke Engineering and Services in cooperation with Baker Environment, Inc.

Figure 3-1
SEAR Well Location Map
Operable Unit 15 - Site 88
MCB Camp Lejeune, North Carolina



NOTE:
THE LOCATION OF THE WELLS WITHIN THE ENLARGED AREA ARE APPROXIMATE

SOURCE: MCB, CAMP LEJEUNE MARCH 2000

LEGEND

- ⊕ – SHALLOW MONITORING WELL
- ⊕ – INTERMEDIATE MONITORING WELL
- ⊕ – DEEP MONITORING WELL
- Ⓡ – RABITT WELL
- ⊕ – INJECTION WELL

FIGURE 3-2 RABITT WELL SAMPLING LOCATION MAP
OPERABLE UNIT No. 15 – SITE 88
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

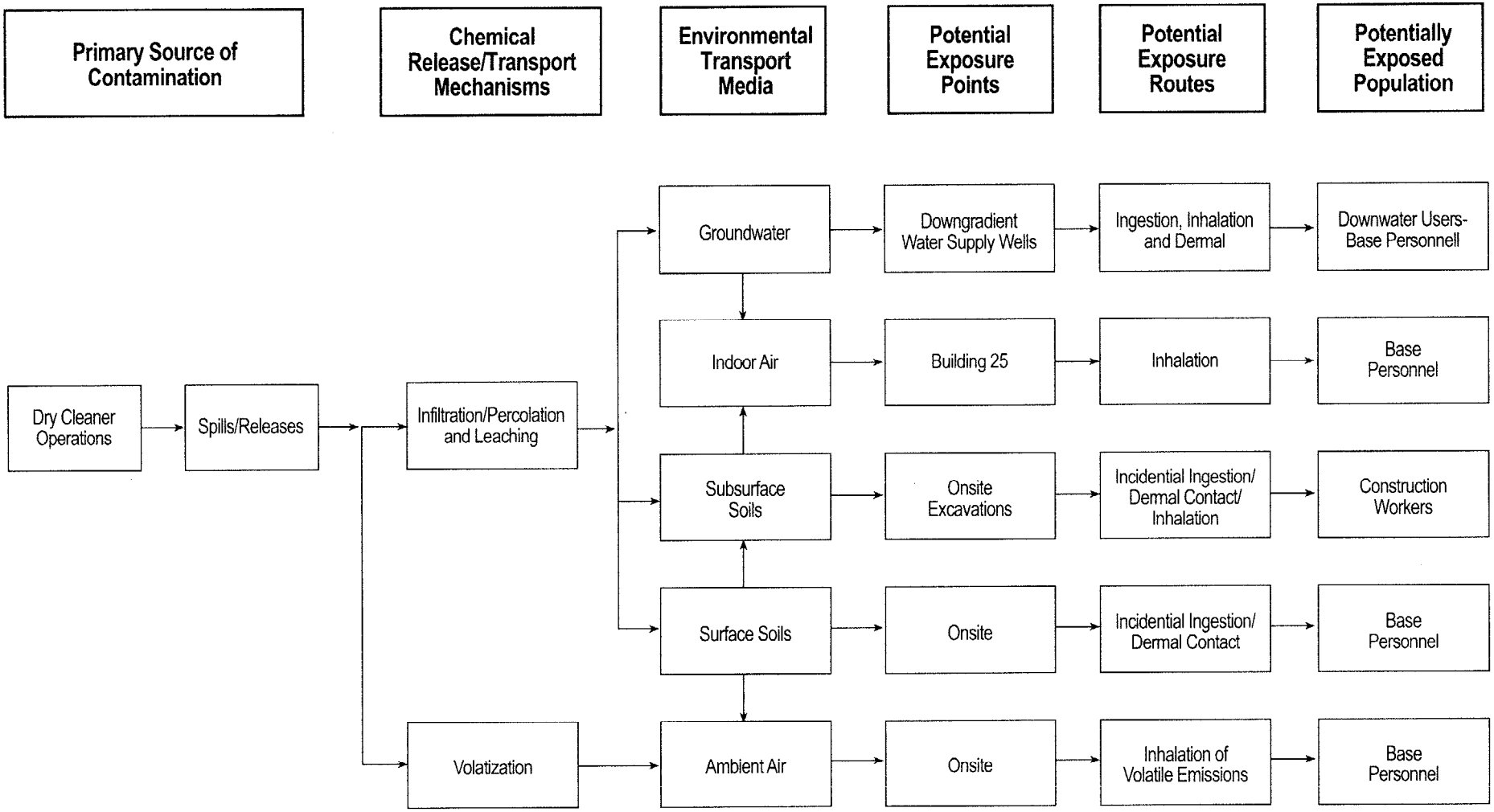


Figure 3-3
Operable Unit 15, Site 88
Conceptual Site Model
RI Work Plan
MCB Camp Lejeune, NC

4 Work Rationale and Investigation Approach

This section provides a rationale for the RI field investigation proposed for the site being investigated and evaluated under this RI. Information is also presented on the work plan development process, the RI objectives, DQOs, design of the data collection program, and other data needs.

4.1 Work Plan Development

This RI work plan has been developed based on the following:

- A review of the RI objectives specified for the site.
- An initial site investigation, including site models, a preliminary assessment of impacts to human health and the environment, an evaluation of the preliminary remedial action objectives, preliminary identification of ARARs, and health-based criteria.
- The DQOs for each site included under the RI, including appropriate analytical data quality levels, analytical detection limits, critical samples, and quality assurance/quality control (QA/QC) samples.

4.2 Data Quality Objectives

DQOs are the quantitative and qualitative descriptions of the data quality required to support an environmental decision or action. As target values for data quality, they are not necessarily criteria for acceptance or rejection of data. The primary DQOs for this project are as follows:

- Assess the extent of contamination in groundwater and soil at Site 88.
- Collect data of sufficient quality to determine the nature and extent of contamination.
- Assess the risk to human and ecological health at Site 88.
- Prepare a Comprehensive RI report for Site 88.
- Prepare a technical memorandum reporting the results of each sampling event.

The primary DQOs for this project were developed in accordance with the EPA's *Guidance for the Data Quality Objectives Process* (EPA, 1994). The 7 step EPA process is:

- Step 1: State the problem – This step was used to define the problem that has initiated the study
- Step 2: Identify the decision – This step defined the decision statement that the study will attempt to resolve.
- Step 3: Identify the inputs to the decision – This step identified the informational inputs that are required to resolve the decision statement.

- Step 4: Define the boundaries of the study – This step defined the spacial and temporal boundaries of the problem.
- Step 5: Develop a decision rule – The purpose of this step was to define the parameter of interest, develop an action level, define the conditions that causes the decision maker to choose among alternative actions.
- Step 6: Specify tolerable limits on decision errors – This step was to identify tolerable limits on decision errors.
- Step 7: Optimize the design for obtaining data – This step was to identify the most resource effective data collection design for generating data that satisfies the stated DQOs.

4.2.1 Step 1 – State the Problem

For this step, planning team members were identified for development of DQOs for the study. Planning team members included the project manager (PM), activity manager (AM), the review team leader (RTL), project geologist, project chemist, and the field team. The goal of the team was to address the data gaps as found in the SSI report (CH2M Hill, 2002).

4.2.2 Step 2 – Identify the Decision

For this step, available information related to the site was studied. This review is documented in Section 3.0 of this work plan. Site evaluation objectives were developed from this review.

4.2.3 Step 3 – Identify Inputs to the Decision

This step identifies the data quality and quantity required to support the decision types of the step 2. Inputs were identified in the SSI report for Site 88 and were drawn from a review of previous studies and current analytical data.

4.2.4 Step 4 – Define the Site Boundaries

For this step, spatial information for Site 88 was reviewed. Site 88 includes the area surrounding Building 25. The site boundary is approximately 300 feet by 225 feet. The study area includes some of the surrounding area as well. The study area is approximately 900 feet by 850 feet. Section. Section 2.0 of this work plan gives a more detailed description of the area around Site 88. **Figure 2-3** is a site map. The temporal boundaries for this project are presented in the proposed project schedule (**Figure 6-2**).

4.2.5 Step 5 – Develop a Decision Rule

For this step, ARARs for the contaminants of concern (COCs) were reviewed. For groundwater, action levels were set as the NCGWQS. If analytical results are above NCGWQS, then groundwater will be considered contaminated. The decision rule was developed from the preliminary conceptual site model located in Section 3.3 of this work plan.

4.2.6 Step 6 – Specify Limits on Decision Errors

For this step the range of contaminants of concern were reviewed. Data from the SSI report were used to establish the range of concentrations for the COCs. Base wide baseline data is currently being gathered by Baker. When this data is available, concentrations will be screened with the baseline levels. Data gathered during this investigation will undergo data validation from an outside vendor. In addition, all data will undergo an internal review.

4.2.7 Step 7 – Optimize the Design for Obtaining Data

The DQOs for this project were developed from the preceding six steps. This step was used to develop the approach for meeting those DQOs. Section 4.3 outlines the designed approach which will be used.

4.3 General Sampling Approach

The proposed investigation will combine a variety of intrusive sampling technologies to locate the sources of contamination, evaluate the nature and extent of contamination, assessing site characteristics, support the development of a risk assessment, and provide input for the development of remedial alternatives. Detailed sampling methodologies are presented in the Field Sampling and Analysis Plan (FSAP) (Appendix A). The vertical and horizontal extent of DNAPL beneath Building 25 has yet to be fully delineated. Building 25 is scheduled for demolition in 2004, and it is understood that this data gap will be investigated at that time.

4.3.1 Nature and Extent

The data collected during the proposed RI, when compiled with existing data, will define the nature and extent of contamination at the site, and allow development of conceptual fate and transport scenarios and facilitate risk analysis.

Sample locations, sample collection methods and analytical procedures are specified in the FSAP (Appendix A). An investigation matrix for the site is show in **Table 4-1. Figure 4-1** shows a flow diagram of the investigation activities.

Figure 4-2 illustrates the proposed soil and groundwater sampling locations at Site 88. DPT borings will be installed first. After the DPT investigation is completed, the data will be used to site the permanent monitoring wells

4.3.1.1 Background Sampling

Baker Environmental is completing a base-wide background study. This study is identifying background concentrations of metals in soil and groundwater.

4.3.1.2 Soil

Soil samples will be collected during the RI to assess the nature and extent of VOCs in soil and evaluate the physical properties of aquifer and aquitard materials.

Soil sampling activities will be conducted along the wastewater conveyance piping in the vicinity of Building 25 and in the unpaved surficial soils on the north side of Building 25.

Soil samples will be collected by DPT equipment. Each soil sample will be field screened using a flame ionization detector (FID) and analyzed for VOCs. Proposed locations of the DPT soil samples are shown in **Figure 4-2**.

Twenty-seven permanent monitoring wells are scoped for Site 88. The specific locations of these wells will be determined by the results of the DPT investigation. All soils will be field screened using a flame ionization detector (FID). Undisturbed soil samples will be collected from each of the deep monitoring well borings and three of the intermediate well borings. Samples will be collected using Shelby tubes, sealed with wax, labeled, and tested for grain size distribution, porosity, and vertical hydraulic permeability.

4.3.1.3 Groundwater

The nature and extent of impacted groundwater will be evaluated at Site 88 during the RI field investigation by sampling of new and existing groundwater monitoring wells in combination with DPT borings.

DPT groundwater sampling activities will be conducted along three north-south transects downgradient of the source area. A total of 24 soil borings are scoped along these transects. The locations of these borings is based on the existing data set for Site 88. Groundwater samples will be collected at 15 foot intervals to an estimated depth of 45 feet. Additionally, 11 soil borings will be advanced along the wastewater conveyance piping in the vicinity of Building 25. Groundwater samples will be taken from approximately 8 feet bgs along the conveyance system. Each groundwater sample will be analyzed in a mobile laboratory for VOCs. Proposed locations of the DPT borings are shown in **Figure 4-2**.

Figure 4-2 shows the location of the existing monitoring wells. The locations of the proposed monitoring wells will be determined following the completion of the DPT borings described in the previous paragraph. The scope of the groundwater investigation activities are summarized in Appendix A.

A total of 26 new wells are planned. The results of the DPT investigation will be used in choosing the precise locations of the wells. A deep well will be installed at an estimated depth of 150 feet in the area of the 88-MW05 cluster. This deep well will be used to establish vertical delineation. The remaining 25 new wells will be installed in nested clusters either at new locations or to supplement existing well clusters. Targeted depths include shallow wells (approximately 25 feet deep), intermediate-depth wells (estimated at 50 feet bgs), and deep wells that extend to the top of the Castle Hayne aquifer (estimated at 85 feet bgs). Precise well construction depths will be determined in the field following review of the boring logs. Soil samples will be collected from the deepest well in each well cluster, as described in Section 4.3.1.2 and Appendix A. **Table 4-1** contains an investigation matrix, which includes the 27 permanent wells to be installed.

Following installation and development of the proposed monitoring wells, all wells will be gauged. These water level measurements will be used to develop site-wide potentiometric maps and to determine groundwater flow patterns within the shallow, intermediate, and deep aquifers. Groundwater samples will be collected from existing and newly installed wells adjacent to Site 88.

Based on the contaminants of concern (COCs) identified under the SSI (CH2M Hill, 2002), groundwater samples from newly installed wells will be analyzed for VOCs, and NAIP, in accordance with the procedures specified in the FSAP (Appendix A).

All screening data such as pH, conductivity, turbidity and temperature will be Level 1 data. All final laboratory analyses will be Level 3. The laboratory data will be validated by an independent third party.

4.3.1.4 Aquifer Testing

Step-drawdown and constant rate pumping tests will be performed on both of the newly installed pumping wells (EX07IW and EX08DW) in order to evaluate aquifer properties, and assess the level of hydraulic communication between the three screened levels. . Existing monitoring wells will be used as observation wells during the pumping test in EX07IW. Observation wells will be installed at the intermediate and deep well depths for the pumping test in EX08DW. The pumping well locations will be determined based on the data collected during the installation of the DPT soil borings. Prior to the commencement of each pumping test, antecedent water levels will be gauged for a period of 24 hours. The step-drawdown tests will be performed over a period of 6 to 8 hours, employing at least 3 or 4 increasing flow rates. A 72-hour constant rate pumping test will be performed in each of the newly installed pumping wells. Following completion of each test, water level recovery will be monitored for a period of at least 12 hours. Barometric pressure readings and background water levels will be monitored throughout the tests. Specific details of the pumping test procedures are presented in Appendix A.

4.4 Risk-Based Actions

The results of the groundwater and soil investigation at Site 88 will be documented in the Comprehensive RI report for Site 88.

The primary objective of the risk assessment (RA) will be to evaluate the potential for human health and ecological risk from exposure to environmental media at Site 88. The results of the proposed investigation at the site will be compared with background concentrations and screening criteria that are protective of human health and the environment. Background soil and groundwater data from the Focused RI report (Baker, 1998) and the Supplemental SI Report (CH2M Hill, 2002), as well as background soil and groundwater samples collected during base-wide background studies, will be used to evaluate onsite data. Potential screening criteria for direct contact and protection of groundwater include relevant North Carolina groundwater quality standards (NCGWQS), preliminary remediation goals (PRGs), and potential federal ARARs (e.g., Maximum Contaminant Levels (MCLs) and ambient water quality criteria [AWQC]). If concentrations in the site's environmental media are below background or these comparison criteria, no further action may be recommended for the site.

Preliminary conceptual exposure models have been developed for the site to ensure that analytical data used in the RA are representative of potentially complete exposure pathways. The following sections provide a summary of current and future land and water uses at the base and surrounding area, and the RA approach that will be used to evaluate Site 88.

4.4.1 Current and Future Land and Water Use

Operable Unit No. 15, Site 88 is located within the Hadnot Point. The Hadnot Point area, which comprises an area of 1,080 acres, consists of a wide variety of land uses. The majority, of this area is taken up by troop housing, recreation, administrative and service buildings. Site 88 is surrounded by troop housing and service buildings. There are no surface water features or groundwater supply wells within 1,500 ft of Site 88. Building 25 is scheduled to be demolished in 2004.

4.4.2 Risk Assessment Approach for Site 88

A preliminary evaluation of potential human exposure pathways for Site 88 is presented in **Figure 3-3**. As additional information is generated throughout the investigation, this preliminary conceptual exposure model will be revised and potential pathways of exposure will be eliminated or added accordingly. The primary sources of chemicals of potential concern (COPC) in environmental media at Site 88 are releases of VOCs at Building 25. COPCs from Site 88 have migrated to groundwater via leaching from surface spills or releases and possible seepage from subsurface stormwater or sewer drains. The most likely current and future receptors at this site are personnel performing utility maintenance operations involving excavation of soil on the north side of Building 25 and along utility easements leading from Building 25. Potential offsite receptors include future offsite groundwater users and ecological receptors.

Based on the current understanding of historical processes and potential releases at the site, VOCs are deemed to be representative of chemicals present at Site 88. Therefore, soil and groundwater will be analyzed for these parameters during this phase of the RI. Samples will also be analyzed for total metals and NAIP.

Soil and groundwater samples representative of current conditions at Sites 88, including data collected during the SSI (CH2M HILL, 2002) and the Focused RI (Baker, 1998), will be used to evaluate the potential for risk to human health and the environment. Historical data for VOCs may not be representative of the current site conditions because these chemicals tend to volatilize and degrade, resulting in diminishing concentrations over time. Therefore, the historical data for VOCs collected prior to 1997 will not be included for quantitative assessment, unless no additional information for an area or medium is available.

Near surface soil samples (zero- to 2-feet bgs) will be used to evaluate potential direct contact with surface soil. Soil from zero to 6-feet bgs will be evaluated for construction worker exposure during potential future excavation. Reasonable maximum exposure (RME) concentrations for soil will be based on the 95% upper confidence limit (UCL) or the maximum detected concentration, whichever is lower. RME concentrations for groundwater will be based on the arithmetic average of wells from the center of the plume for VOCs.

Characterization of potential risk will be based on a comparison of exposure concentrations for soil and groundwater with relevant screening criteria known to be below regulatory or health concerns. Soil and groundwater data from Site 88 will be evaluated using cleanup target levels. These screening criteria and Contract Required Detection Limits (CRDLs) and Method Detection Limits (MDLs) for proposed analytical methods are summarized in **Table 4-2**. If concentrations in environmental media are below background and/or the selected

criteria, NFA may be recommended for the site. If a chemical exceeds the screening criteria, it will be selected as a COPC and evaluated further in a baseline risk assessment.

Tables

TABLE 4-1
Investigation Matrix for Operable Unit 15, Site 88
MCB Camp Lejeune
Camp Lejeune, North Carolina

Station ID	Drilling and Well Construction				Soil Sampling						Groundwater Sampling		Other			
	Estimated Depths (ft. bgs)								Laboratory Analyses				Aquifer Testing			
	Rotosonic boring	HSA boring	DPT boring	Monitoring Well Screened Interval	Field Screening (FID)	Disturbed *HSA or Rotosonic*	Undisturbed (Shelby tube) *HSA or Rotosonic*	DPT (soil cores)	Geotechnical	Analytical	DPT Borehole GW Samples	GW - Wells	Slug Test	Pumping Test	Well Gauging	Natural Gamma logs
					C - Continuous, I - Intervals of X feet											
Site Delineation																
88-MW08R		22.0		7.0 to 22.0	C	I = 5						A			X	
88-MW11		22.0		7.0 to 22.0	C	I = 5						A	X		X	
88-MW12		22.0		7.0 to 22.0	C	I = 5						A			X	
88-MW13		22.0		7.0 to 22.0	C	I = 5						A			X	
88-MW14		22.0		7.0 to 22.0	C	I = 5						A	X		X	
88-MW15		22.0		7.0 to 22.0	C	I = 5						A			X	
88-MW16		22.0		7.0 to 22.0	C	I = 5						A	X		X	
88-MW01IW	50.0			45.0 to 50.0	C	C	2[a]		n,p,s	A		A			X	
88-MW06IWR	50.0			45.0 to 50.0	C	C						A			X	
88-MW08IWR	50.0			45.0 to 50.0	C	C						A			X	
88-MW11IW	50.0			45.0 to 50.0	C	C						A	X		X	
88MW12IW	50.0			45.0 to 50.0	C	C						A			X	
88-MW13IW	50.0			45.0 to 50.0	C	C						A			X	
88-MW14IW	50.0			45.0 to 50.0	C	C						A	X		X	
88-MW15IW	50.0			45.0 to 50.0	C	C	2[a]		n,p,s	A		A			X	
88-MW16IW	50.0			45.0 to 50.0	C	C	2[a]		n,p,s	A		A	X		X	
88-MW17IW	50.0			45.0 to 50.0	C	C						A			X	
88-MW06DW	85.0			80.0 to 85.0	C	C	3[a]		n,p,s	A		A			X	X
88-MW07DW	85.0			80.0 to 85.0	C	C	3[a]		n,p,s	A		A			X	X
88-MW08DW	85.0			80.0 to 85.0	C	C	3[a]		n,p,s	A		A			X	X
88-MW09DW	85.0			80.0 to 85.0	C	C	3[a]		n,p,s	A		A	X		X	X
88-MW11DW	85.0			80.0 to 85.0	C	C	3[a]		n,p,s	A		A	X		X	X
88-MW17DW	85.0			80.0 to 85.0	C	C	3[a]		n,p,s	A		A			X	X
88-MW05DW-2	150.0			145.0 to 150.0	C	C						A			X	X
88-EX07IW	55.0			35.0 to 55.0	C	C	2[a]		n,p,s	A		A		S/C	X	
88-EX08DW	85.0			65.0 to 85.0	C	C	3[a]		n,p,s	A		A		S/C	X	X
DPT-1 - DPT-35			49.0		C			I = 4			A, I = 15					
Utility Trenches																
DPT-1 - DPT-8			49.0		C			I = 4			A					
Existing Wells																
88-MW01												B			X	
88-MW02												B			X	
88-MW02DW												B			X	X

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TABLE 4-1
Investigation Matrix for Operable Unit 15, Site 88
MCB Camp Lejeune
Camp Lejeune, North Carolina

	Drilling and Well Construction				Soil Sampling						Groundwater Sampling		Other			
	Estimated Depths (ft. bgs)								Laboratory Analyses				Aquifer Testing			
Station ID	Rotosonic boring	HSA boring	DPT boring	Monitoring Well Screened Interval	Field Screening (FID)	Disturbed *HSA or Rotosonic*	Undisturbed (Shelby tube) *HSA or Rotosonic*	DPT (soil cores)	Geotechnical	Analytical	DPT Borehole GW Samples	GW - Wells	Slug Test	Pumping Test	Well Gauging	Natural Gamma logs
					C - Continuous, I - Intervals of X feet											
88-MW02IW												B			X	
88-MW03												B			X	
88-MW03DW												B			X	X
88-MW03IW												B			X	
88-MW04												B	X		X	
88-MW04DW												B	X		X	X
88-MW04IW												B	X		X	
88-MW05												B			X	
88-MW05DW												B			X	X
88-MW05IW												B			X	
88-MW06												B			X	
88-MW07												B			X	
88-MW07IW												B			X	
88-MW09												B			X	
88-MW09IW												B			X	
88-MW10IW												B			X	
EX01												B			X	
EX02												B			X	
EX04												B			X	
EX04R												B			X	
EX05												B			X	
EX06												B			X	
HC02												B			X	
IN01												B			X	
IN02												B			X	
IN03												B			X	
IW01												B			X	
RABITTIMW1												B			X	
RABITTIW1												B			X	
RABITTIW2												B			X	
RABITTIW3												B			X	
RABITTMW2												B			X	
RABITTMW3												B			X	
RABITTMW4												B			X	
RABITTMW5												B			X	
RABITTMW6												B			X	
RABITTMW7												B			X	
RABITTMW8												B			X	
RABITTMW9												B			X	
RW01												B			X	
RW02												B			X	
RW04												B			X	

TABLE 4-1
Investigation Matrix for Operable Unit 15, Site 88
MCB Camp Lejeune
Camp Lejeune, North Carolina

	Drilling and Well Construction				Soil Sampling						Groundwater Sampling		Other			
	Estimated Depths (ft. bgs)								Laboratory Analyses				Aquifer Testing			
Station ID	Rotosonic boring	HSA boring	DPT boring	Monitoring Well Screened Interval	Field Screening (FID)	Disturbed *HSA or Rotosonic*	Undisturbed (Shelby tube) *HSA or Rotosonic*	DPT (soil cores)	Geotechnical	Analytical	DPT Borehole GW Samples	GW - Wells	Slug Test	Pumping Test	Well Gauging	Natural Gamma logs
					C - Continuous, I - Intervals of X feet											

Notes:

1. Monitoring wells will be constructed with 2" Sch. 40 PVC well casing and 0.010" slotted well screen, extraction wells will be constructed with 4" Sch. 40 PVC well casing and 0.010" slotted well screen
2. A = samples to be analyzed for VOCs
3. B = samples to be analyzed for VOCs, MNA, and all previously observed exceedances
4. S/C = Step-drawdown and 72-hour constant rate aquifer pumping test
5. TBD = To be determined
6. N= porosity, p= permeability, s= sieve analysis

a - Shelby tube samples will be collected from intervals (where the intervals units are found) of 20 - 22 ft bgs (silty aquitard), 45 - 47 ft bgs (fine sand aquifer), and 70 - 72 ft bgs (silty fine sand aquitard)
b - encore samples to be taken from the base of shelby tube samples

TABLE 4-2
Target Lists, Minimum Reporting Limits, and Minimum QC Criteria
Quality Assurance Project Plan, Site 88, MCB Camp Lejeune

Analyte	Soil (mg/kg)				Groundwater (µg/L)			
	Method	Minimum RL	% Recovery	Precision	Method	Minimum RL	% Recovery	Precision
Volatile Organic Compounds (VOCs)								
1,1-Dichloroethane	8260B	0.010	70-130	30	8260B	1	75-125	30
1,1-Dichloroethylene	8260B	0.010	70-130	30	8260B	1	75-125	30
1,1,1-Trichloroethane	8260B	0.010	70-130	30	8260B	1	75-125	30
1,1,2-Trichloroethane	8260B	0.010	70-130	30	8260B	1	75-125	30
1,1,2,2-Tetrachloroethane	8260B	0.010	70-130	30	8260B	1	75-125	30
1,2-Dichloroethane	8260B	0.010	70-130	30	8260B	1	75-125	30
1,2-Dichloroethene	8260B	0.010	70-130	30	8260B	1	75-125	30
1,2-Dichloropropane	8260B	0.010	70-130	30	8260B	1	75-125	30
2-Butanone (MEK)	8260B	0.025	70-130	30	8260B	10	75-125	30
2-Hexanone	8260B	0.010	70-130	30	8260B	1	75-125	30
4-Methyl-2-pentanone (MBK)	8260B	0.025	70-130	30	8260B	10	75-125	30
Acetone	8260B	0.025	70-130	30	8260B	10	75-125	30
Benzene	8260B	0.010	70-130	30	8260B	1	75-125	30
Bromodichloromethane	8260B	0.010	70-130	30	8260B	1	75-125	30
Bromoform	8260B	0.010	70-130	30	8260B	1	75-125	30

TABLE 4-2
Target Lists, Minimum Reporting Limits, and Minimum QC Criteria
Quality Assurance Project Plan, Site 88, MCB Camp Lejeune

Analyte	Soil (mg/kg)				Groundwater (µg/L)			
	Method	Minimum RL	% Recovery	Precision	Method	Minimum RL	% Recovery	Precision
Bromomethane	8260B	0.010	70-130	30	8260B	1	75-125	30
Carbon disulfide	8260B	0.010	70-130	30	8260B	1	75-125	30
Carbon tetrachloride	8260B	0.010	70-130	30	8260B	1	75-125	30
Chloroethane	8260B	0.010	70-130	30	8260B	1	75-125	30
Chlorobenzene	8260B	0.010	70-130	30	8260B	1	75-125	30
Chloroform	8260B	0.010	70-130	30	8260B	1	75-125	30
Chloromethane	8260B	0.010	70-130	30	8260B	1	75-125	30
cis-1,3-Dichloropropene	8260B	0.010	70-130	30	8260B	1	75-125	30
Dibromochloromethane	8260B	0.010	70-130	30	8260B	1	75-125	30
Ethylbenzene	8260B	0.010	70-130	30	8260B	1	75-125	30
Isopropanol	8260B	0.010	70-130	30	8260B	1	75-125	30
Isopropylbenzene	8260B	0.010	70-130	30	8260B	1	75-125	30
Methylene chloride	8260B	0.025	70-130	30	8260B	10	75-125	30
Styrene	8260B	0.010	70-130	30	8260B	1	75-125	30
Tetrachloroethylene	8260B	0.010	70-130	30	8260B	1	75-125	30
Toluene	8260B	0.010	70-130	30	8260B	1	75-125	30
Total xylenes	8260B	0.025	70-130	30	8260B	10	75-125	30

TABLE 4-2
Target Lists, Minimum Reporting Limits, and Minimum QC Criteria
Quality Assurance Project Plan, Site 88, MCB Camp Lejeune

Analyte	Soil (mg/kg)				Groundwater (µg/L)			
	Method	Minimum RL	% Recovery	Precision	Method	Minimum RL	% Recovery	Precision
trans-1,3-Dichloropropene	8260B	0.010	70-130	30	8260B	1	75-125	30
Trichloroethene	8260B	0.010	70-130	30	8260B	1	75-125	30
Vinyl chloride	8260B	0.010	70-130	30	8260B	1	75-125	30
Metals								
Antimony	6010B or 7041	0.5	75-125	30	6010B or 7041	25	80-120	25
Arsenic	6010B or 7060	1	75-125	30	6010B or 7060	5	80-120	25
Beryllium	6010B	0.5	75-125	30	6010B	25	80-120	25
Cadmium	6010B	0.5	75-125	30	6010B	25	80-120	25
Chromium	6010B	1	75-125	30	6010B	5	80-120	25
Copper	6010B	2.5	75-125	30	6010B	125	80-120	25
Lead	6010B or 7421	0.3	75-125	30	6010B or 7421	3	80-120	25
Mercury	7470/7471	0.1	75-125	30	7470/7471	1	80-120	25
Nickel	6010B	4.0	75-125	30	6010B	20	80-120	25
Selenium	6010B or 7740	0.5	75-125	30	6010B or 7740	25	80-120	25
Silver	6010B	1.0	75-125	30	6010B	5	80-120	25
Thallium	6010B or 7841	1.0	75-125	30	6010B or 7841	5	80-120	25

TABLE 4-2
Target Lists, Minimum Reporting Limits, and Minimum QC Criteria
Quality Assurance Project Plan, Site 88, MCB Camp Lejeune

Analyte	Soil (mg/kg)				Groundwater (µg/L)			
	Method	Minimum RL	% Recovery	Precision	Method	Minimum RL	% Recovery	Precision
Zinc	6010B	2.0	75-125	30	6010B	10	80-120	25
General Chemistry								
Ethene	RSK 175	3.0	75-125	25	NA	NA	NA	NA
Ethane	RSK 175	2.0	75-125	25	NA	NA	NA	NA
Methane	RSK 175	1.0	75-125	25	NA	NA	NA	NA
Chloride	USEPA 300	2.0	75-125	25	NA	NA	NA	NA
TOC	SW 846 9060	5.0	75-125	25	NA	NA	NA	NA
Sulfate	USEPA 300	5.0	75-125	25	NA	NA	NA	NA
Sulfide	USEPA 376.1	0.5	75-125	25	NA	NA	NA	NA
Nitrate	USEPA 300	0.05	75-125	25	NA	NA	NA	NA
Nitrite	USEPA 300	0.05	75-125	25	NA	NA	NA	NA

Figures

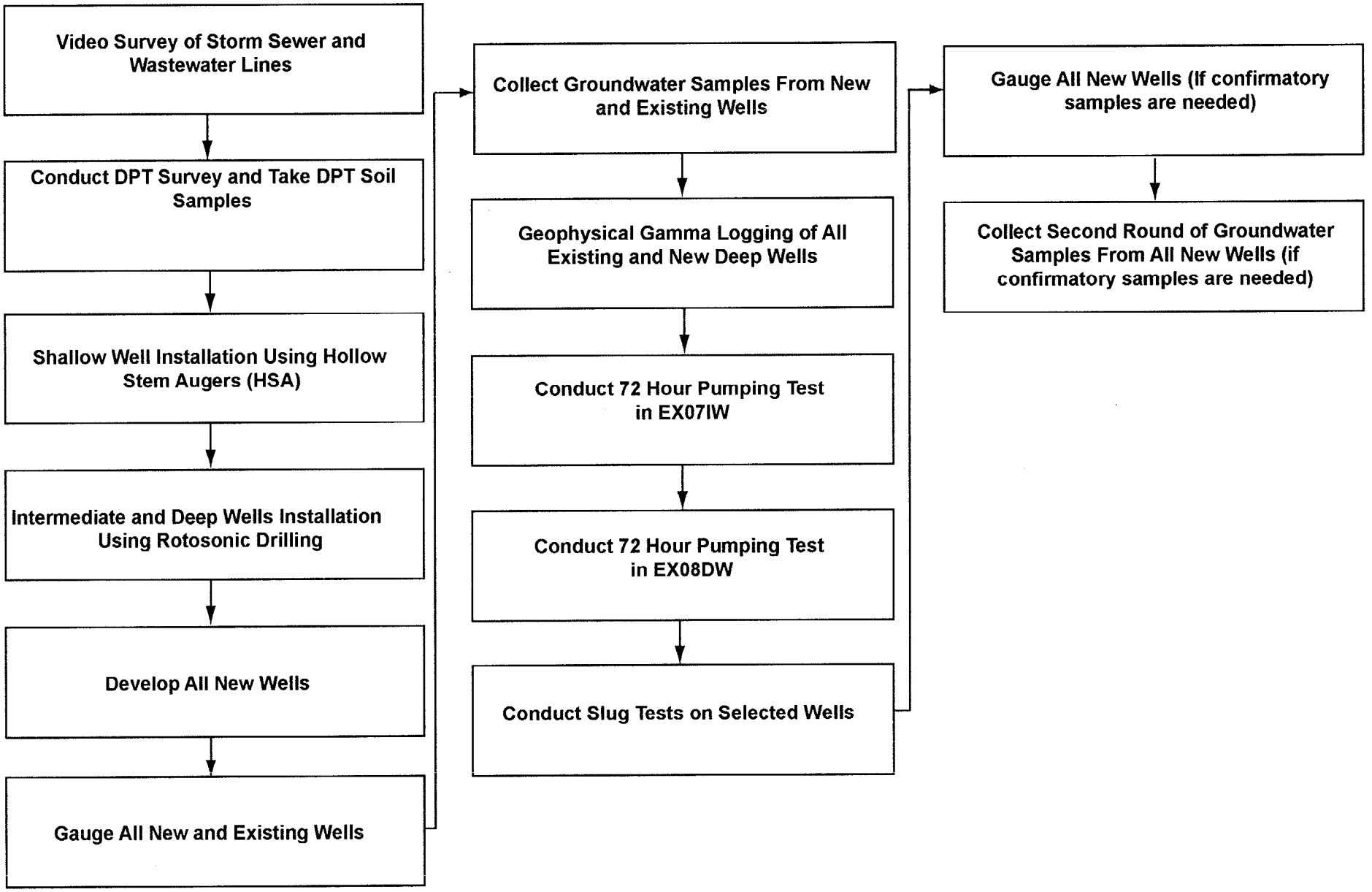
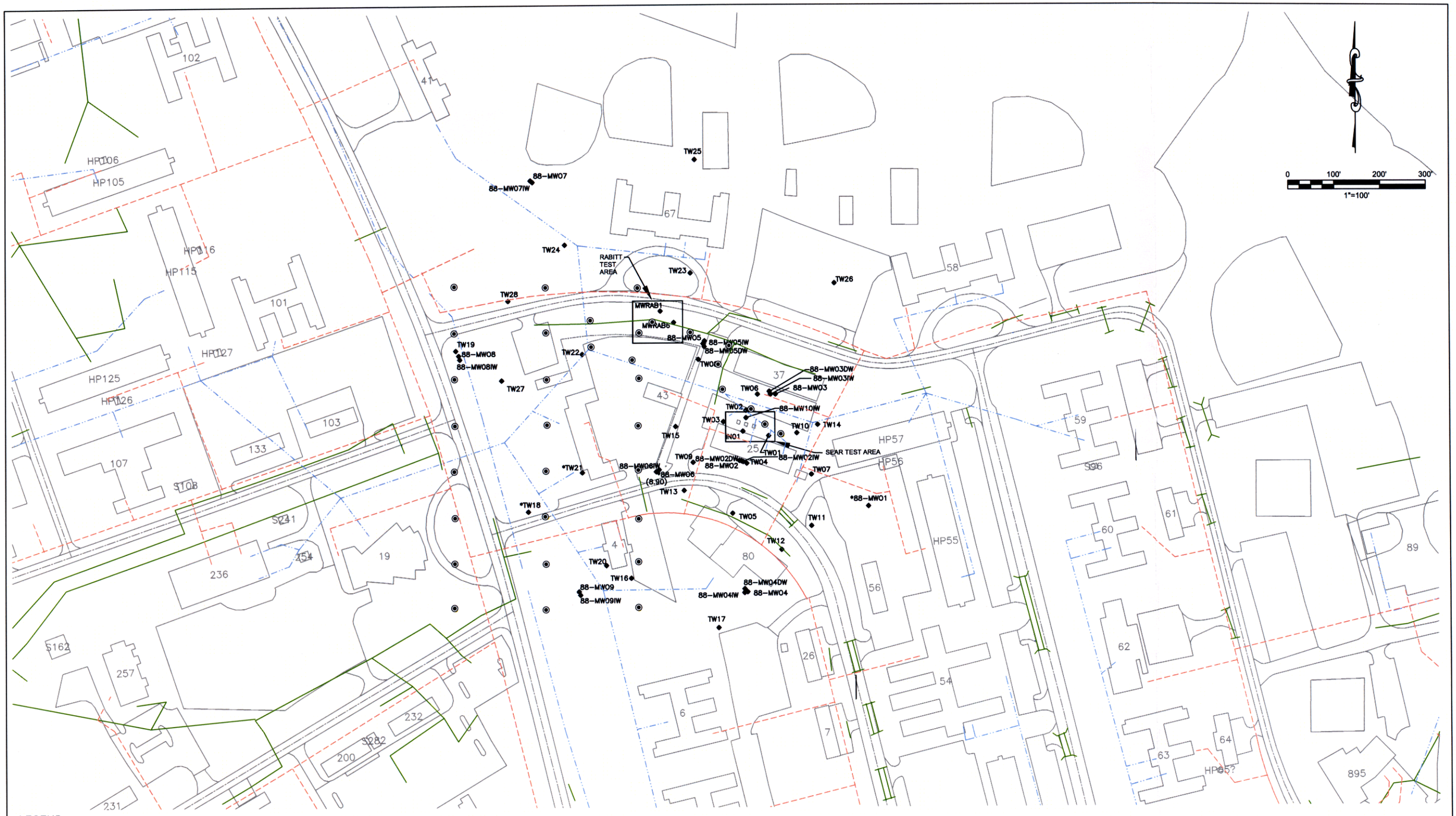


Figure 4-1
Operable Unit 15, Site 88
RI Work Plan
MCB Camp Lejeune, NC



LEGEND

- ◆ – SHALLOW MONITORING WELLS
- ◆ – INTERMEDIATE MONITORING WELLS
- ◆ – DEEP MONITORING WELLS
- ◉ – PROPOSED DPT BORING

- UTIL–HEAT–COOL–LINE1
- UTIL–STORM–SEWER–LINE
- UTIL–WASTEWATER–LINE
- UTIL–WATER–LINE

Figure 4-2
Proposed DPT Borings
OPERABLE UNIT NO. 15 – SITE 88
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

CH2MHILL

CAD1/PROJECTS/CHARLOTTE/CAMP LEJEUNE/4056
SOURCE: MCB, CAMP LEJEUNE MARCH 2000

5 Site Evaluation Tasks

5.1 Project Management

Project management functions will include planning and implementation of the project, internal and external communication with the project team and the Partnering Team, project meetings, and managing day-to-day functions.

5.2 Subcontractor Procurement

A total of ten subcontractors will be required for the RI investigation. A utility locator will be used for underground utility location. A video surveying company will conduct video surveys of the conveyance system. A Geoprobe™ will conduct DPT sampling. A geophysical company will log boreholes using gamma ray technology. A drilling company will drill soil borings and install monitoring wells, using rotosonic, hollow-stem augers, and DPT. A mobile laboratory may be used to analyze soil samples collected with DPT. An analytical laboratory will analyze soil and groundwater samples. A geotechnical lab will provide geotechnical analysis of the undisturbed soil samples. A NC-licensed land surveying company will survey the locations and elevations of the monitoring wells, soil borings, and other sampling locations. A suitable electrical supply will be installed by an electrical subcontractor at the two pumping wells to facilitate conducting the step drawdown and 72-hour pumping tests. Procurement of subcontractors will be performed in accordance with Navy Clean Contract Procurement Manual.

5.3 Field Investigations

Field investigation activities will be conducted at Site 88 under this work plan. Although some degree of detailed information exists for the site, additional characterization is still necessary. The RI field investigation will focus on three goals for the site:

- Defining the physical nature and characteristics of the site
- Defining any existing or residual sources of contamination
- Delineating the nature and extent of contamination at the site

The RI objectives, appropriate analytical quality levels, and a design of the data collection program are presented in Section 4 - Investigation Approach. Additional information is also provided in the FSAP (Appendix A) and the Quality Assurance Project Plan (QAPP) (Appendix B). The data collection program goals are consistent with protocols established by EPA for investigation of hazardous waste sites and the LANTDIV policy. The Health and Safety Plan (HASP) is presented in Appendix C. This plan will serve as the health and safety guide during the site characterization field activities.

5.4 Sample Analysis, Validation, and Data Evaluation

Chemical analysis will be performed by CLP-approved laboratories. The selected laboratory will perform all analyses at a QA/QC level consistent with the DQOs. The QAPP addresses the required analyses for each sample type. If necessary, the methods will be modified to the extent possible to meet required detection limits or in the event that additional types of analyses such as synthetic precipitation leaching procedure (SPLP) or toxicity characteristic leaching procedure (TCLP) analyses are warranted.

Data reduction procedures are present in the QAPP (Appendix B). After being received from the laboratory, the data will be validated in accordance with the applicable method criteria, as outlined in the most current versions of the following EPA documents:

- Laboratory Data Validation, Functional Guidelines for Evaluating Organics Analysis,
- Laboratory Data Validation, Functional Guidelines for Evaluating Inorganics Analysis

5.5 Risk Evaluation

A baseline risk assessment (human health and ecological) will be prepared for Site 88 under this RI and will include site-specific recommendations regarding whether the site should be considered for "no further action" or whether it should proceed to the feasibility study phase of the project. A draft baseline risk assessment will be submitted with the draft RI. Review comments will be addressed in the final baseline risk assessment. The RI will be conducted in accordance with EPA Region IV requirements for human health and ecological risk assessments.

5.6 Report

A draft RI Report will be produced following the general format, as presented in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final* (1988). This format is presented in **Table 5-1**. The RI Report will document the RI field investigation and analytical activities and results. The draft RI Report will be submitted to the Partnering Team for review. Review comments will be addressed in the final RI Report.

Table 5-1
Suggested Remedial Investigation Report Format
MCB Camp Lejeune, O.U. 15, Site 88 RI Work Plan
Camp Lejeune, NC

TABLE OF CONTENTS
LIST OF FIGURES
LIST OF TABLES
LIST OF ACRONYMS/ABBREVIATIONS
EXECUTIVE SUMMARY
1.0 INTRODUCTION
2.0 FACILITY BACKGROUND

Table 5-1
Suggested Remedial Investigation Report Format
MCB Camp Lejeune, O.U. 15, Site 88 RI Work Plan
Camp Lejeune, NC

3.0 ENVIRONMENTAL SETTING

4.0 FIELD PROGRAM
- **4.1 SUMMARY**
- **4.2 DEVIATIONS FROM THE WORK PLAN**
- **4.3 FIELD SCREENING ACTIVITIES**
- **4.4 CONFIRMATION ACTIVITIES**
- **4.5 INVESTIGATION-DERIVED WASTE**

5.0 INVESTIGATION FINDINGS
- **5.1 BASEWIDE GEOLOGIC AND HYDROLOGIC INVESTIGATION RESULTS**
- **5.2 BACKGROUND SAMPLING RESULTS**
- **5.3 SITE FINDINGS**
  - **5.3.1 Geologic and Hydrologic Investigation Results**
  - **5.3.2 Screening Results**
  - **5.3.3 Soils**
  - **5.3.4 Groundwater**
  - **5.3.5 Conclusions**

6.0 DISCUSSION OF ARARs

7.0 CONTAMINANT FATE AND TRANSPORT
- **7.1 POTENTIAL ROUTES OF MIGRATION**
- **7.2 CONTAMINANT OF PERSISTENCE**
- **7.3 CONTAMINANT MIGRATION**

8.0 BASELINE RISK ASSESSMENT
- **8.1 CHEMICAL AND PHYSICAL PROPERTIES OF CONTAMINANT OF CONCERN**
- **8.2 HUMAN HEALTH EVALUATION**
- **8.3 ECOLOGICAL EVALUATION**

9.0 CONCLUSIONS

10.0 RECOMMENDATIONS

11.0 REFERENCES

APPENDICES

TECHNICAL MEMORANDA ON FIELD ACTIVITIES
FIELD CHANGE REQUEST FORMS
SCREENING RESULTS
PIEZOMETER/MONITORING WELL CONSTRUCTION DIAGRAMS
BORING/WELL LOGS
AQUIFER TESTING RESULTS
CHAIN OF CUSTODY
ANALYTICAL DATA AND QA/QC EVALUATION RESULTS (Include data validation reports)
INVESTIGATION-DERIVED WASTE MANAGEMENT

6 Project Management and Schedule

This section of the Work Plan briefly describes the project management organization, responsibilities of project personnel, records maintenance and documentation, coordination of subcontractor activities, work permit requirements, procedures for Work Plan deviations, internal quality control, and the project schedule and deliverables. The implementation of an effective management plan will help ensure that the objectives of the RI are achieved.

6.1 Project Staffing and Responsibilities

The project organization is presented in **Figure 6-1**. The Partnering team includes representatives from CH2M Hill, LANTDIV, Camp Lejeune, North Carolina Department of Environmental and Natural Resources (NC DENR), EPA Region IV, Baker Environmental and Shaw Group.

Mr. Tegwyn Williams, P.G. is the CH2M HILL Project Manager for the RI. He is the primary CH2M HILL contact and is responsible for overall project management and the overall quality assurance and quality control (QA/QC) of project deliverables. He will be assisted by Mr. Christopher Bozzini, P.E., who serves as CH2M HILL's CLEAN II Activity Manager for Camp Lejeune. Mr. Bozzini will provide overall guidance with regards to LANTDIV and Camp Lejeune and will serve as the alternate CH2M HILL contact.

Mr. Sam Shannon, P.G., will serve as the Senior Review for the RI. Mr. Shannon will review the technical aspects of the work from project scoping to project completion.

The project team will include: the Project Hydrogeologist, Risk Assessors, Field Team Leader (FTL), and Site Safety Coordinator (SSC). All field and subcontractor activity will be under the direction of the Field Team Leader.

6.2 Project Schedule

The proposed schedule for the RI for MCB Camp Lejeune Site 88 is presented in **Figure 6-2** and is dependent on the availability of government funding. The tasks presented in the RI schedule correspond to the RI tasks identified in this Work Plan.

6.3 Data Management Plan

The CH2M HILL Data Management Plan describes procedures to document and track investigation data and results. The plan includes:

- Data documentation and processing procedures
- Project-related progress reporting procedures
- Project file requirements

Implementation of the procedures described herein will ensure documentation and retrieval of data and results.

6.3.1 Data Documentation and Processing Procedures

During the RI, three types of data will be generated: field data, laboratory data, and investigation results. This subsection presents documentation and processing procedures for the data.

Field Data

The RI field team will document all field activities in a bound field logbook. In addition, any visits to the site by regulatory personnel or their contractors will be documented in the field logbook. The log book will also document all deviations from the work plan. The field logbook will have consecutively numbered pages with water-resistant surface sizing on the paper. Waterproof ink, preferably black, will be used to record entries in the field logbook. Each page of the field logbook will be dated and signed by the individual making the entries. The field logbook should provide a summary of the field activities.

For most sampling activities, specific sampling and information forms will be used to record the activities. The sampling team will record additional physical and geological information and any field measurements (e.g., pH, temperature, etc.) taken during sampling. Such forms also allow space for recording any unusual conditions encountered during sampling (e.g., difficulties with the sampling equipment, post-sampling contamination or loss of samples). Examples of these forms are included in the FSAP (Appendix A).

A sample identification system will be used to identify each sample in accordance with Camp Lejeune protocol. An identification label will be affixed on each sample container sent to the laboratory. The sample identification system for the RI is described in the FSAP (Appendix A).

A copy of all sampling and information forms and chain-of-custody records will be made available upon request.

Laboratory Data

Upon arrival at the laboratory, the samples will be cross-referenced against the chain-of-custody records. Any mislabeling will be identified, investigated, and corrected prior to logging the samples into the laboratory. The samples will be logged in at every storage area and work station required by the designated analyses. Individual analysts will verify the completeness and accuracy of the data recorded on the forms.

Raw data will be entered by the analysts in bound laboratory notebooks. A separate book will be maintained for each analytical procedure. All calculations will be entered into designated laboratory notebooks with a sufficient amount of data to compute without reference to other documents. A tracking form will be used to show that at least 10 percent of all calculations have been checked by the analyst and the laboratory QA Supervisor from the raw data to the final value stages prior to reporting the results of a group of samples. This form, as well as all logs and calculations, will be made available for any QA audit conducted during the investigation.

Instrument calibration logs and internal quality control procedures will be documented in accordance with the analytical method in use. All proposed analytical methods have been documented in detail in the FSAP (Appendix A). Documentation of these activities will be made available during QA audits.

The reporting requirements will be in accordance with the CLP Statement of Work OLM01.0 for organics analysis and ILM01.0 for inorganics analysis, or other specified analytical method.

A data package will be submitted along with the monthly report for the month when CH2M HILL receives that data package. Also, copies of all the analytical data reports, including the QC data, will be included as appendices to the RI report, as supplied by the laboratory. Index tables will be developed for each media sampled to indicate where in the appendix specific analytical or QC data could be found.

Investigation Results

The results of the RI will be presented in tabular and graphical formats. The raw data will be included in a tabular format in appendices of the RI report. The following data will be presented in tables:

- Water level elevations
- Sampling location coordinates
- Comparative data between study areas and background areas

Graphs or figures will be used to depict the following:

- Layout and topography
- Sampling locations
- Boundaries of sampling locations
- Stratigraphy and water level elevations
- Horizontal extent of contamination
- Vertical distribution of contaminants

6.2.2 Project File Requirements

This project will require the administration of a central project file. The data and records management protocols will provide adequate controls and retention of all materials related to the project. Record control will include receipt from external sources, transmittals, transfer to storage and indication of record status. Record retention will include receipt at storage areas, indexing, filing, storage, maintenance, and retrieval.

Record Control

All incoming materials related to the project, including sketches, correspondence, authorizations, and logs, shall be forwarded to the Project Manager or designated assistant. These documents will be placed in the project file. Project personnel will work from a copy of the necessary documents. All records shall be legible and easily identifiable.

Examples of the types of records that will be maintained in the project file are:

- Field documents
- Correspondences
- Photographs
- Laboratory data
- Reports
- Procurement agreements

Outgoing project correspondence and reports will be reviewed and signed by the Project Manager.

Record Status

To prevent the inadvertent use of obsolete or superseded project-related procedures, the Project Team Members will be responsible for reporting changes in protocol to the CH2M HILL Project Manager. The Project Manager will then inform other members of the Project Team and the Project Quality Assurance Officer of these changes.

Revisions to procedures shall be subject to the same level of review and approval as the original document. The revised document will be distributed to all holders of the original document and discussed with project personnel. Outdated procedures will be marked "void." One copy of a document marked "void," along with the reason(s) for marking the document "void" will be maintained in the project file. In addition, the date a document is marked "void" will be recorded.

Record Storage

All project related information will be maintained by CH2M HILL. Designated personnel will assure that incoming records are legible and are in suitable condition for storage. Record storage will be performed in two stages:

- Storage during and immediately following the project
- Permanent storage of records directly related to the project

CH2M HILL will use storage facilities that provide a suitable environment that will minimize deterioration or damage and prevent loss. Records will be secured in steel file cabinets labeled with the appropriate project identification. CH2M HILL will use Excel for Windows by Microsoft for data storage. Data will be maintained on diskette and a backup will be created each time a file is edited. Upon presentation of data to MCB Camp Lejeune , a backup of that version will be permanently stored in the central filing location.

At the completion of the project, the Project Manager or his appointed document custodian will be responsible for the project file inventory. All material from the project file, including drawings, project related quality QA documents, and electronic project documentation and verification records will be maintained by CH2M HILL.

6.4 Reporting Requirements

Monthly progress reports will be submitted to LANTDIV in accordance with the requirements under the CLEAN Program. The RI process includes major submittals for the RI. These are:

- Draft Work Plan including FSAP, QAPP and HASP
- Final Work Plan
- Draft RI
- Final RI

Figures

Figure 6-1. Project Organization

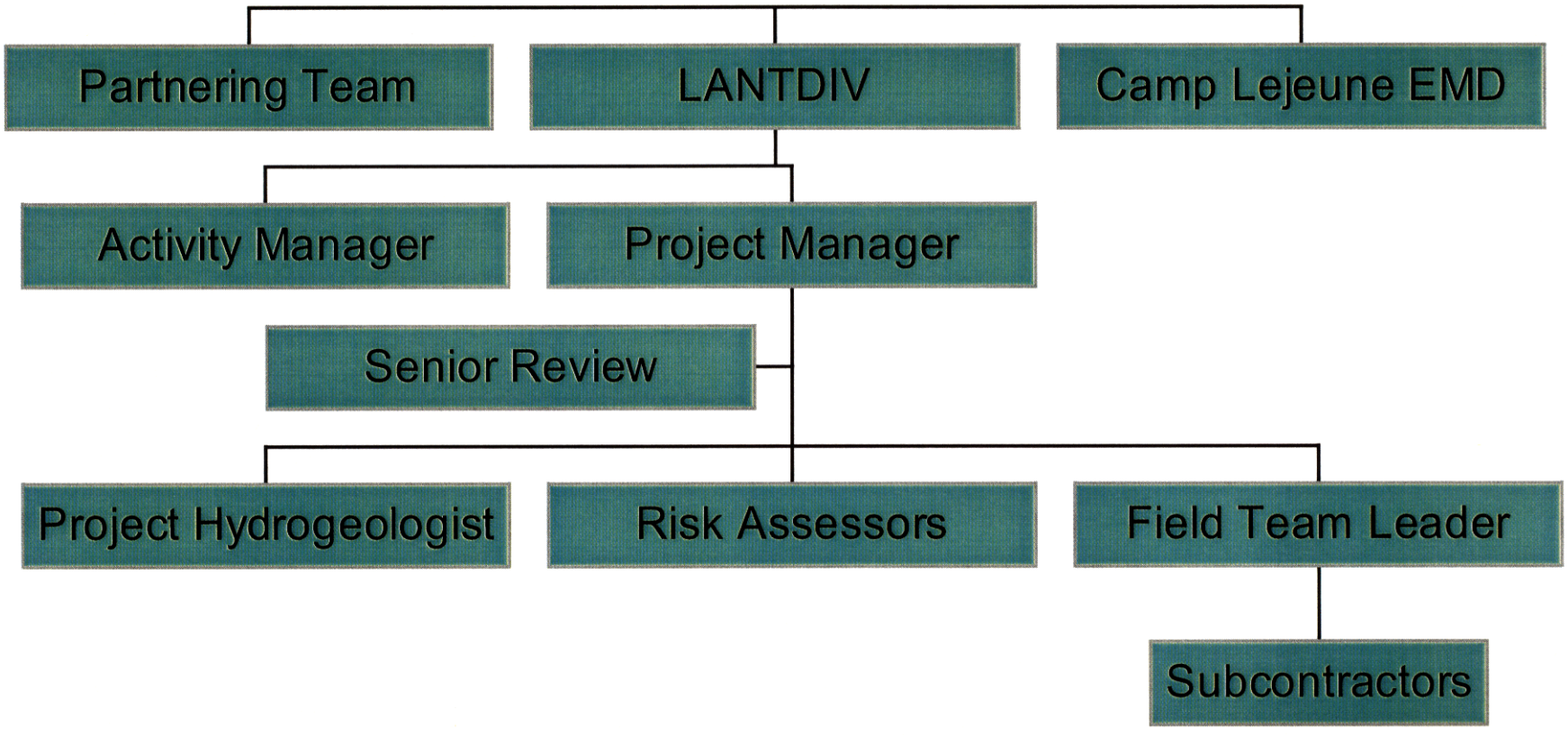
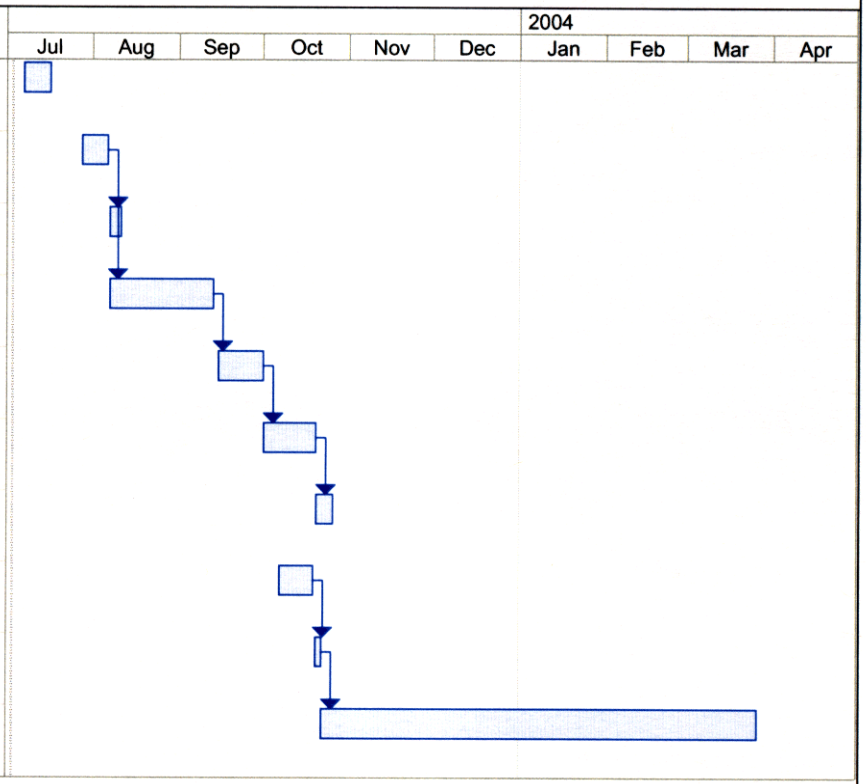


Figure 6-2
Proposed Project Schedule

ID	Task Name	Start	Finish
1	Video Survey of Sewer Lines	Mon 07/07/03	Wed 07/16/03
2	Geoprobe Borings	Mon 07/28/03	Wed 08/06/03
3	Shallow Well Installation (7 wells)	Thu 08/07/03	Mon 08/11/03
4	Intermediate (11 wells) and Deep (8) Well Installation	Thu 08/07/03	Sat 09/13/03
5	Develop All New Wells	Mon 09/15/03	Wed 10/01/03
6	Sample all wells (new & existing)	Wed 10/01/03	Mon 10/20/03
7	Geophysical gamma logging of all deep wells	Mon 10/20/03	Sun 10/26/03
8	Conduct 72 hr pump test on intermediate and deep wells	Tue 10/07/03	Sun 10/19/03
9	Conduct Slug Tests (8)	Mon 10/20/03	Wed 10/22/03
10	Prepare Comprehensive RI Report	Wed 10/22/03	Fri 03/26/04



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Appendix A

FINAL

Site 88 Sampling & Analysis Plan

Operable Unit No. 15 (Site 88)

Marine Corps Base

Camp Lejeune, North Carolina

Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

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LANTDIV Clean II Program

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Prepared by

CH2MHILL

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Acronyms and Abbreviations

AOCs	Areas of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Above ground Storage Tank
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
bgs	Below Ground Surface
BMI	Battelle Memorial Institute
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPC	Chemicals of Potential Concern
COC	Contaminants of Potential Concern
CRDLs	Contract Required Detection Limits
CSF	Cancer Slope Factor
CTO	Contract Task Order
DCE	Dichloroethene
DEM	Division of Environmental Management
DNAPL	Dense Non-Aqueous Phase Liquids
DoN	Department of Navy
DOT	Department of Transportation
DPT	Direct Push Technology
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EMD	Environmental Management Divisions
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
Fm.	Formation
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
FSP	Field Sampling Plan
FWS	Fish and Wildlife Service
HA	Health Advisories
HASP	Health and Safety Plan
HI	Hazard Index
ICR	Incremental Lifetime Cancer Risk

IR	Installation Restoration
IRP	Installation Restoration Program
kg	Kilogram
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCB	Marine Corps Base
MCLs	Maximum Contaminant Limits
MDLs	Method Detection Limits
mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
msl	Mean Sea Level
NAIPS	Natural Attenuation Indicator Parameters
NAVFAC	Naval Facilities Engineering Command
NC DENR	North Carolina Department of Environmental and Natural Resources
NCP	National Oil and Hazardous Substances Pollution and Contingency Plan
NCWQS	North Carolina Water Quality Standards
NFA	No Further Action
NWI	Nation Wetlands Inventory
OSHA	Occupational Safety and Health Administration
PCE	Tetrachloroethene
PAH	Polynuclear Aromatic Hydrocarbons
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goals
QA/QC	Quality Assurance/ Quality Control
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RABITT	Reductive Anaerobic Insitu Treatment Technology
RAGS	Risk Assessment Guidance for Superfund
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RRRS	Relative Risk Ranking System
SARA	Superfund Amendments and Reauthorization
SCS	Soil Conservation Service
SEAR	Surfactant Enhanced Aquifer Remediation
SI	Site Investigation
SPLP	Synthetic Precipitation Leaching Procedure

SSI	Supplemental Site Investigation
TAL	Total Analyte List
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
UCL	Upper Confidence Limit
UST	Underground Storage Tank
USC	United States Code
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
VOCs	Volatile Organic Compounds
WQS	Water Quality Standards

A.1 Introduction

This document has been prepared to serve as the Field Sampling Plan (FSP) for the remedial investigation (RI) at Operable Unit 15, Site 88 at the Marine Corps Base (MCB) Camp Lejeune in Onslow County, North Carolina. This FSP sets forth procedures for field activities and the analysis of soil and groundwater samples.

Subcontractors will be furnished with copies of the project-specific FSP. Subcontractors will be expected to adhere to the procedures specified in this document. All field activities will be conducted by CH2M HILL or subcontractors under the direct supervision of CH2M HILL.

A.2 Site Background

This section provides a brief history of Site 88 and previous environmental investigations. Section 1 of the Work Plan provides a detailed project description. Section 2 describes the site background and environmental setting.

A.2.1 Site History and Contaminants

Operable Unit 15, Site 88 is located within the boundaries of MCB Camp Lejeune on Post Lane Road, approximately 500 feet east of the intersection of Post Lane Road and Main Service Road. The site consists of the Base Dry Cleaning Facility (Building 25) and the surrounding grassy and paved areas (Work plan, **Figure 2-3**). Site 88 is surrounding by troop housing and service buildings.

Beginning in the 1940s, Varsol™ was stored in underground storage tanks (USTs) located on the north side of Building 25. In the 1970s, Varsol™ was replaced by tetrachloroethene (PCE), which was stored in an aboveground storage tank (AST). PCE was reportedly stored in the AST from the 1970s until the mid-1980s. Facility employees reported that spent PCE was disposed of in floor drains. In March 1995, two self-contained dry cleaning machines were installed in Building 25, thus eliminating the need for bulk storage of PCE. The USTs were removed in November 1995.

A.2.2 Summary of Existing Site Data

Previous investigations at Site 88 include the focused remedial investigation (RI) performed by Baker Environmental in 1996 and 1997, the Surfactant-Enhanced Aquifer Remediation (SEAR) pilot test performed in 1999, the Reductive Anaerobic In-Situ Treatment Technology (RABITT) pilot test performed in 2001, and the supplemental site investigation (SI) performed by CH2M HILL in 2002. The need for additional work is based on the findings presented in the September 2002 Draft Supplemental SI Report and the May 1998 Final Focused RI Report.

A.3 Sampling Objectives

The purpose of the RI is to address the remaining data gaps and to complete the identification and delineation of the releases at Site 88. The specific project objectives are as follows:

- More completely document the potential effects of solvent disposal into the wastewater conveyance system. This work will include video surveys of the stormwater and wastewater sewer lines associated with Building 25.
- Assess the horizontal and vertical extent of the chlorinated solvent release in soil and groundwater.
- Investigate the thickness, lateral continuity, and permeability of the lower confining unit for the shallow surficial aquifer beneath the site.
- Evaluate the hydraulic conductivity among the shallow, intermediate, and deep aquifers beneath Site 88.
- Demonstrate that biological degradation is the dominant physical process that is occurring in the shallow aquifer.
- Evaluate fate and transport of the chlorinated solvents within soil and groundwater.
- Prepare a Comprehensive Final RI Report summarizing the findings of the investigation.

Soil and groundwater sampling will be conducted within, and immediately surrounding, Site 88. All analytical data will be collected, analyzed, and validated to provide a Level 3 data package. Data requirements are detailed in the site-specific *Quality Assurance Project Plan* (Appendix B).

A.4 Sample Locations and Frequency

The remedial investigation at Site 88 includes the following field activities:

- Video surveys of the wastewater conveyance system
- Groundwater sampling using Direct Push Technology (DPT)
- Installation and development of shallow, intermediate, and deep groundwater monitoring wells
- Collection and analysis of soil and groundwater samples
- Aquifer testing
- Geophysical gamma logging of the deep groundwater monitoring wells
- Surveying

Each activity is described in more detail below. **Table 4-1** in the Work Plan summarizes the proposed field activities, including the number and type of samples that will be collected at each location. Proposed sampling locations are shown in **Figure 4-2** in the Work Plan.

A.4.1 Video Survey

One of the primary investigation objectives for Site 88 is to more completely document the potential effects of solvent disposal into the wastewater conveyance system. This work includes evaluating the condition of the underground wastewater conveyance system using video camera surveys.

Base engineering drawings will be used to identify underground utility easements. Video surveys of the stormwater and wastewater sewer line will be conducted in order to identify areas of deterioration that may have allowed leaks into the subsurface. The video surveys will be used in conjunction with existing soil and groundwater chemical and physical data to select appropriate sampling locations along the underground utility corridors. Work Plan **Figure 4-2** shows the specific utility easements to be video surveyed.

A.4.2 DPT Borings

Direct push technology (DPT) borings will be used to evaluate the potential for contaminant migration along the utility corridors (designated as DPT 1 through 35) as well as the extent of lateral and downgradient groundwater contamination. Proposed boring locations are shown in the Work Plan **Figure 4-2**. Eight soil borings (DPT-1 through DPT-8) will be drilled along the utility trenches and other biased source area locations. The remainder of the borings will be distributed in a grid pattern to the west of Building 25.

Soil samples will be screened in the field using an FID. Ambient air quality will be monitored for volatile organic vapors using the appropriate instrument listed in the *Health and Safety Plan* (Appendix C). Groundwater grab samples will be collected from each DPT boring at 15 foot intervals and analyzed by an on site laboratory for VOCs.

A dual-tube DPT method will be employed within the vicinity of Building 25 and at other locations where the surficial aquifer is found to be impacted. This method allows for installation of a temporary surface casing (3-inch inside diameter DPT core barrel) to limit possible cross-contamination during advancement of the deeper portions of the DPT borehole. Generally, following collection of the groundwater sample from the shallow sampling zone (15 to 19 feet bgs), the temporary casing will be advanced to a depth of approximately 22 feet below ground surface, corresponding with a silty clay layer that has been identified in the vicinity of Building 25. Once in place, the borehole may be advanced to the intermediate (30 to 34 feet bgs) and deep (45 to 49 feet bgs) sampling zones. Upon completion of the sampling activities, each borehole will be abandoned in accordance with Section A.4.5.

A.4.3 Soil Borings

Following completion of the DPT sampling activities, a total of 26 soil borings will be drilled at locations surrounding Site 88 using hollow stem auger (HSA, for shallow borings only) or rotosonic (intermediate and deep borings) drilling methods. The locations of the borings will be selected based upon the findings of the DPT investigation. These borings are intended to further characterize site lithology and to provide boreholes for permanent groundwater monitoring well construction. The approximate depths of the soil borings will be:

- Seven shallow borings (approximately 25 feet bgs),
- Eleven intermediate depth borings (approximately 55 feet bgs),
- Seven deep borings (approximately 85 feet bgs), and
- One deep boring (approximately 150 feet bgs)

The use of temporary casings will be necessary during drilling and construction of the intermediate and deep soil borings in order to seal off the shallow and intermediate aquifer zones, respectively. Rotosonic casings may be used as isolation casings during well construction. However, the outer isolation casing must be advanced to the required depth prior to advancing an intermediate casing (if required) or installing the inner casing. Temporary casings will not be grouted. Table A.4-1 provides a summary of temporary casing requirements.

For the intermediate depth borings, the surficial aquifer will need to be cased-off by installing a temporary isolation casing at least one foot into the silty aquitard (approximately 22 feet bgs) prior to advancing the borehole to the target depth of approximately 50 feet bgs. For the seven (7) deep borings installed to approximately 85 feet bgs, the surficial zone and intermediate zone will need to be cased-off prior to advancing the borehole to the target depth. For the deep boring installed to approximately 150 feet

bgs, the surficial, intermediate, and deep zones will need to cased-off prior to advancing the borehole to the target depth.

Soil Sampling

During HSA drilling of the shallow soil borings, soil samples will be collected from each boring for lithologic characterization and field screening, and will be obtained using standard 2-foot long split-spoon. Soil samples will be collected in accordance with ASTM Method D-1586, *Standard Method for Penetration Test and Split-Barrel Sampling of Soils*. Split-spoon samples will be collected at five foot intervals from the ground surface down to the desired depth of the borehole. During rotosonic drilling activities, continuous nominal 3-inch diameter soil cores will be collected for lithologic characterization and field screening as the boreholes are advanced. Samples will be collected from the ground surface down to the desired depth of the borehole. Ambient air quality will be monitored for volatile organic vapors using the appropriate instrument listed in the *Health and Safety Plan* (Appendix C).

Undisturbed soil samples will be collected from each of the eight (8) deep well borings, using Shelby tubes from the following depths:

- Approximately 20 to 22 feet bgs (silty aquitard layer),
- Approximately 45 to 47 feet bgs (a fine sand aquifer), and
- Approximately 70 to 72 feet bgs (a silty fine sand aquitard layer)

Undisturbed samples will also be collected from the silty aquitard layer and the fine sand aquifer from each of three (3) intermediate well borings (those not associated with a deep well). The drilling subcontractor will be responsible for the advancement and retrieval of the Shelby tube at the desired depths within each borehole. Following retrieval, the Shelby tube shall be sealed at both ends using molten wax. These samples will be submitted for geotechnical testing for porosity, permeability, and grain size distribution, as described in Table 4-1 and Section A.7.

Discrete soil samples will be collected at intervals corresponding to the shallow, intermediate and deep aquifer zones, from the deepest boring in each location and analyzed for VOCs. Soils will be screened for VOCs using an FID. Soil boring and sampling procedures are described in Section A.6.1. A CH2M HILL geologist will visually describe and log each sample and record the data on a soil boring log (see Attachment 1).

A.4.4 Monitoring Well Installation

Permanent groundwater monitoring wells will be installed in the 26 borings. The monitoring well boreholes will be bored, drilled, or augered as close to vertical as possible. Slanted boreholes are not acceptable unless specified in the Work Plan. The depth and volume of the borehole should be calculated and the appropriate materials procured before starting drilling activities.

The use of temporary casings will be necessary during drilling and construction of the intermediate and deep well borings in order to seal off specific aquifer zones as the borehole

is advanced. Rotosonic casings may be used as isolation casings during well construction. However, the outer isolation casing must be advanced to the required depth prior to advancing an intermediate casing (if required) or installing the inner casing. Temporary casings will not be grouted. Table A.4-1 provides a summary of well casing requirements.

TABLE A.4-1

Summary of Well Casing Requirements

Well Type	Temporary Isolation Casings				Inner Casing[1]		Screen[2]
	Outer		Intermediate				
	Diameter (inches)	Depth (feet bgs)	Diameter (inches)	Depth (feet bgs)	Diameter (inches)	Length (feet)	Length (feet)
Intermediate MW	7	22*	NA	NA	2	45	5
Intermediate EW	10	22*	NA	NA	4	30	20
Deep MW (a)	10	22*	8	70	2	80	5
Deep MW (b)	10	22*	8	110	2	145	5
Deep EW	10	22*	8	60	4	65	20

Notes:

1 – Schedule 40 PVC,
2 - Schedule 40 PVC, 0.010-inch machine slotted
* - Approximate depth (+/- 2 feet)
MW – Monitoring well
EW – Extraction well
NA – Not applicable

For the intermediate depth wells, the surficial aquifer will need to be cased-off by installing a temporary isolation casing at least one foot into the silty aquitard (approximately 22 feet bgs) prior to advancing the borehole to the target depth of approximately 50 feet bgs. For the seven (7) deep wells installed to approximately 85 feet bgs, the surficial zone and intermediate zone will need to be cased-off prior to advancing the borehole to the target depth. For the deep well installed to approximately 150 feet bgs, the surficial, intermediate, and deep zones will need to cased-off prior to advancing the borehole to the target depth.

The borehole will be of sufficient diameter so that well construction can proceed without major difficulties. A minimum 2-inch annular space is required between the casing and the borehole wall to allow the filter pack, bentonite pellet seal, and the annular grout to be placed at the specified intervals at an acceptable thickness using a tremie tube.

Wells will be installed after soil and/or discrete groundwater samples are collected and the boreholes have been drilled to the depths indicated by the FTL. For shallow wells, the screened interval will be placed to intersect the seasonal water table. For deep wells, the screened interval will be placed on the basis of lithology. Well construction details will be recorded on the Well Completion Form (**Attachment 2**) and in the field logbook.

Well Casing and Well Screen Assembly

Well casings and screens will be new and unused. Well casings, screens, and end caps will be assembled and installed to prevent damage to the sections and joints. No lubricating oils, solvents, grease, or pipe dope will be used on casing threads. Teflon® tape will be used to wrap the threads to ensure a tight fit and minimize leakage. No glue of any type will be used to secure casing joints. O-rings will not be used and will be removed prior to well assembly. A temporary well cap will be placed on top of the well casing and screen assembly during installation of the annular materials.

Monitoring wells

Well casings will consist of factory-made flush-threaded 2-inch-diameter, Schedule 40 PVC. Well screens for the shallow monitoring wells will consist of 15 feet of factory-made flush-threaded machine-slotted 2-inch-diameter, Schedule 40 PVC. Well screens for the intermediate and deep monitoring wells will consist of 5 feet of factory-made flush-threaded machine-slotted 2-inch-diameter, Schedule 40 PVC. A well screen slot size appropriate for the geologic formation encountered (probably 0.010-inch) will be selected. A factory-made flush-threaded 2-inch-diameter, Schedule 40 PVC end cap will be placed on the bottom of each well screen. Flush-threaded joints will be compatible for monitoring well casings, screens, and end caps. The seven (7) deep monitoring wells shall be equipped with stainless steel centralizers, attached to the riser pipe approximately three feet above the top of the screened interval

Extraction Wells

Two wells will be constructed for the purposes of conducting aquifer pumping tests. One (1) intermediate well and one (1) deep well will be constructed using a 20-foot section of 4-inch ID, Schedule 40, 0.010-inch machine-slotted PVC screen with a bottom cap set at the bottom of the borehole. The screen will be connected to threaded, flush-joint, PVC riser. The 4-inch diameter wells will be completed in the same manner as the 2-inch diameter PVC wells. "O"-rings will be removed prior to assembly. The deep well shall be equipped with a stainless steel centralizer, attached to the riser pipe approximately three feet above the top of the screened interval. The riser casing will be installed to be approximately a few inches below the ground surface. A watertight, locking, expansion cap will be installed on top of the PVC well casing at the surface.

Sand Filter Pack Installation

A sand filter pack will be placed around the well screen using the positive displacement method, tremie method, or other approved method. The well screen and casing will remain suspended and centered in the borehole until the annular materials have completely settled.

After the well casing and screen assembly are set at the appropriate depth, the sand filter pack will be placed into the borehole. The sand filter pack will consist of a thoroughly washed, sound, durable sand of an appropriate grain size, containing less than 5 percent silt or clay for the well screen slot size selected (commercially available 20/30-grain size or equivalent for 0.010-inch slot size). No organic material, anhydrite, gypsum, mica, or calcareous material will be allowed. No water will be used to place the filter pack unless approved by the FTL. The filter pack will be installed in approximate 2-foot lifts to prevent

bridging. The depth to the top of the sand filter pack will be measured periodically using a weighted measuring tape. The sand filter pack will be installed to a depth of at least 1-foot above the top of the well screen.

Bentonite Seal

A bentonite seal will be placed on top of the filter pack using the tremie method, or other approved method. The bentonite pellets will be poured into the borehole. The bentonite seal will consist of 30 percent solids in the form of bentonite pellets. Approximately 2 feet of bentonite pellets will be placed above the sand filter pack. The depth to the top of the bentonite seal will be measured and documented to ensure that the transition seal meets design requirements. The bentonite will be allowed to hydrate for 30 to 45 minutes prior to emplacement of the cement-bentonite grout.

Cement-Bentonite Grout Annular Seal

A cement-bentonite grout annular seal will be placed on top of the bentonite seal using the tremie method. The tremie pipe shall be designed to distribute cement grout horizontally within the borehole and not vertically downward to limit potential for displacement of the bentonite seal, e.g. the end of the deepest section of tremie pipe must be plugged and large slots must be cut into the sides of the pipe. The grout seal will extend from the top of the bentonite seal to within 2 feet of the ground surface. The grout seal will consist of Portland Type I cement conforming to ASTM C-150 standards. The cement-bentonite grout will be mixed using a maximum of 7 gallons of water per 94-pound bag of cement and a maximum of 2.7 pounds of bentonite per 94-pound bag of cement. The bentonite powder will either be mixed into the water prior to adding the cement or mixed into the cement powder prior to adding water. The grout will be mixed thoroughly before being placed in the borehole

If used, the temporary isolation casings (beginning with the inner-most casing) shall be gradually withdrawn as grout is pumped into the borehole. The Subcontractor shall ensure that the rate of casing removal does not exceed the rise of the grout within the borehole. The driller will provide a mud scale to demonstrate that the cement grout return at the ground surface is within 3 percent of the weight of the cement grout being pumped into the hole. This will provide documentation that significant grout dilution by groundwater is not occurring.

The grout will be allowed to cure for a minimum of 24 hours before development or well completion.

Placement of the cement grout may displace volatile organic vapors, therefore ambient air quality shall be monitored using the appropriate instrument listed in the *Health and Safety Plan* (Appendix C).

Surface Completion

The type of flush mounted well completion depend on the location of the well. Surface pads will consist of concrete at least 4 inches thick and 2-feet square centered on the well. A lockable, water-tight cap or cover made specifically for the diameter of the well casing will be placed on each well. Locks will be made of brass and will be keyed alike.

For flush-mounted well completions in paved areas, concrete and asphalt will be removed from around the well to create a 2-foot-square opening in the pavement. The well will be centered in the opening. A concrete saw will be used to cut the opening. A jackhammer or similar tool may be required to remove the concrete pavement. Jagged-edged or out-of-square openings will not be permitted. The surface pad will be oriented with any cultural features located nearby. An 8-inch-diameter vault will be placed over the well 0.25-inch above the existing pavement surface. The surface of the concrete pad will slope gradually from the vault surface to the existing pavement surface at the edge of the pad. The vault will be centered in the 2-foot-square pavement opening. Each vault will have bolt-on traffic-bearing iron covers. The slab will be reinforced with four 20-inch-long steel reinforcing rods (#3 minimum size) placed uniformly around the vault within the concrete slab. The concrete surface will be finished smoothly, and a metal survey marker will be embedded in the fresh concrete.

For flush-mounted well completions in unpaved areas, soil will be removed and leveled around the well to create a 2-foot-square opening for a concrete form. The well will be centered in the opening and concrete form. A shovel or similar tool may be required to remove and level the soil. Jagged-edged or out-of-square openings will not be permitted. The surface pad will be oriented with any cultural features located nearby. An 8-inch-diameter vault will be placed over the well 0.50-inch above the existing ground surface. The surface of the concrete pad will slope gradually from the vault surface to the existing ground surface at the edge of the pad. The vault will be centered in the 2-foot-square concrete form and opening. Each vault will have bolt-on traffic-bearing iron covers. The vault will be centered in the 2-foot-square concrete slab, with each vault having bolt-on traffic-bearing iron covers. It is not expected that reinforcement of the slab will be necessary at MCB Camp Lejeune Site 88. If reinforcement is necessary, the slab will be reinforced with four 20-inch-long steel reinforcing rods (#3 minimum size) placed uniformly around the vault within the concrete slab. The concrete surface will be finished smoothly, and a metal survey marker will be embedded in the fresh concrete.

A.4.5 Soil Boring and Monitoring Well Abandonment Procedures

DPT soil borings will be abandoned upon completion of sampling activities. However, monitoring wells will not be abandoned without permission from MCB Camp Lejeune. Applicable MCB, State of North Carolina, and EPA procedures and guidelines for borehole and monitoring well abandonment will be followed.

The objective of abandoning a soil boring or monitoring well is to prevent the introduction of surface water runoff or impacted groundwater from migrating along the boring, monitoring well, or annular space of the monitoring well. The following procedure will be used to abandon boreholes and monitoring wells.

1. Obstructions in the borehole or well that could interfere with abandonment will be removed.

2. Residual drilling fluids and other fine detritus will be purged from the borehole or well.

3. Well casing materials will be removed where practical to ensure placement of an effective seal.

4. When the well casing is not properly grouted, the upper 20 feet of casing, at a minimum, must be removed.

5. The borehole or well will be sealed with an impermeable filler, such as neat cement grout.

All abandoned soil borings and monitoring wells will be grouted from the bottom of the borehole or well up to ground surface using a bentonite-cement grout consisting of Portland Type I cement conforming to ASTM C-150 standards. The cement-bentonite grout will be mixed using a maximum of 7 gallons of water per 94-pound bag of cement and a maximum of 2.7 pounds of bentonite per 94-pound bag of cement. The bentonite powder will either be mixed into the water prior to adding the cement or mixed into the cement powder prior to adding water. The grout will be mixed thoroughly before being placed into the borehole.

The Subcontractor shall ensure that the rate of drill casing removal (if present) does not exceed the rise of the grout within the borehole. The driller will provide a mud scale to demonstrate that the cement grout return at the ground surface is within 3 percent of the weight of the cement grout being pumped into the hole. This will provide documentation that significant grout dilution by groundwater is not occurring.

Placement of the cement grout may displace volatile organic vapors, therefore ambient air quality shall be monitored using the appropriate instrument listed in the *Health and Safety Plan* (Appendix C).

The purpose of abandoning a soil boring or monitoring well completed in a confined aquifer is to retain water in the aquifer to prevent cross-contamination of aquifers. Where several confined aquifers are present in an abandoned monitoring well, impermeable seals are required between water-bearing sections. It is not anticipated that confined aquifer soil borings or monitoring wells will be abandoned as part of the scope of work for this Work Plan.

A.4.6 Monitoring Well Development

A new well will be developed within 48 hours after installation depending upon scheduled field activities. A new well will not be developed for at least 24 hours after the surface pad and outer protective casing or vault are installed to allow sufficient time for the well materials to cure before development procedures are initiated. Development equipment will be decontaminated as specified in this Work Plan. Development water will be containerized and disposed of in the Lot 203 treatment system.

Wells will be developed by surging and over pumping with a submersible pump using the following procedure.

1. Remove the well cap or cover and monitor for volatile organic vapors using the appropriate instrument listed in the *Health and Safety Plan* (Appendix C).

2. Measure the depth to water in the well and the total well depth with a clean electronic water level indicator. Calculate the volume of standing water in the well.

3. Lower the submersible pump into the well. Turn the pump on as it is lowered into the water column and lower the pump slowly to develop the entire water column and avoid clogging the pump with sediment. Slowly surge the screened interval to draw sediment from the sand pack into the well. Alternately pump and surge the screened interval until the water is relatively clear and free of visible sediment.

4. After each well volume of water is removed, measure and record the pH, temperature, specific conductance, and turbidity of the water using the Well Development Form (**Attachment 3**).

5. Continue well development until the water is relatively clear and free of visible sediment. Well development will be considered complete after a minimum of three well volumes of water have been removed and the pH, specific conductance, temperature, and turbidity have stabilized. If the parameters have not stabilized within five volumes, it is at the discretion of the FTL whether or not to continue well development.

With respect to the volume of groundwater, adequate well development is normally achieved when the column of water in the well is free of visible sediment. Typically, several volumes of standing water in the well will be removed during well development.

With respect to groundwater chemistry, adequate development is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized and the turbidity has either stabilized or is below 10 NTUs. Ten NTUs is twice the primary drinking water standard and is the goal for most groundwater sampling objectives. Stabilization occurs when pH measurements remain constant within 0.1 standard unit (SU), specific conductance varies no more than 10 percent, and the temperature is constant for three consecutive readings.

A.4.7 Monitoring Well Gauging and Sampling

Water level measurements will be collected from the 45 existing and 26 new groundwater monitoring wells (Work Plan **Figure -4-2**). These measurements will be used to develop site-wide potentiometric maps and to determine groundwater flow patterns within the shallow, intermediate, and deep aquifers.

Groundwater samples will be collected from all site monitoring wells and submitted for laboratory analysis of VOCs, metals and NAIPs. Well purging and sampling procedures are described in Section A.6.5.

A.4.8 Aquifer Testing

Aquifer testing activities will consist of slug tests, step-drawdown tests, and 72-hour constant-rate tests. Existing monitoring wells will be used as observation wells during the pumping test in EX07. Observation wells will be installed at the intermediate and deep well depths for the pumping test in EX08. The pumping and observation well locations will be

determined based upon the results of the DPT investigation. The following sections describe the procedures to be followed.

Slug Test

Slug tests will be completed in the new groundwater monitoring wells to determine the hydraulic conductivity, transmissivity, and groundwater seepage velocity of the surficial aquifer. The screened intervals of the wells tested will be below the water table.

The slug test will consist of submerging a PVC or stainless-steel cylinder of known volume (slug) in a test well, allowing the static water level time to equilibrate, rapidly removing the slug, and recording the changes in head over time. The test will be allowed to continue until the water level returns to within 10 percent of the original static water level.

Equipment used for the slug test will include a data logger and pressure transducer, a nylon rope, and a solid PVC or stainless-steel slug. Prior to the initial slug test and between each well tested, all downhole equipment will be decontaminated according to the procedures described in this Work Plan.

Slug testing will be completed using the following procedure:

1. Remove the well cap or cover and monitor for volatile organic vapors using the appropriate instrument listed in the *Health and Safety Plan* (Appendix C).
2. Measure the depth to water in the well and the total well depth using a clean electronic water level indicator. Calculate the groundwater elevation and the height of the water column. If the well screen is not fully submerged in the water column, then the data reduction methods must be modified accordingly. If the pressure transducer and slug cannot be fully submerged in the water column, then the well should be evaluated for slug response. If a non-fully submerged slug will result in adequate drawdown, then the test should be performed. Otherwise, the well should not be used to perform a slug test.
3. Lower the pressure transducer into the well and suspend in the water column in the screened interval.
4. Lower the slug into the well and suspend in the water column above the pressure transducer.
5. Enter the appropriate test parameters into the data logger and set the zero reference point after the water column has stabilized to near original static conditions. The transducers should be programmed to record water level data on a logarithmic time scale with the maximum time interval of 2 minutes (the minimum time interval should be automatically determined by the datalogger, but should not exceed 0.05 seconds).
6. Start the pressure transducer and immediately remove the slug from the water column. Be careful not to bump the pressure transducer.
7. Record the change in head over time until readings have stabilized. The water level should be allowed to recover a sufficient amount of time to allow the rate of inflow into the well to be controlled by the formation rather than by storage in the filter pack.

Reduce the data by plotting the change in head versus time on semi-logarithmic paper using the Bouwer and Rice method of analysis (Bouwer, 1987) or other appropriate data reduction method.

Step-Drawdown Test

Step-drawdown tests will be performed on both of the newly installed pumping wells (EX07 and EX08) in order to evaluate specific capacity of each well, and determine a suitable discharge rate for the 72-hour pumping test.

An electric submersible pump equipped with a variable frequency drive (e.g. Grundfos Rediflo) should be used for the step-drawdown test. Therefore, a reliable and 'clean' source of electrical power should be identified and a temporary electrical outlet should be installed in the immediate vicinity of the pumping wells.

The pump should be installed within the pumping well at the mid-screen interval (approximately 40 feet bgs in the intermediate well, and 75 feet bgs in the deep well). Discharge from the pump should be routed to a temporary holding tank. The holding tank should be sized to contain the entire discharge from a single step-drawdown test. Arrangements should be made with Shaw Group to empty the contents of the tank at the completion of the test.

Step-drawdown tests will be performed in both pumping wells over a period of 6 to 8 hours, employing at least 3 or 4 increasing flow rates. Water level fluctuations in the pumping wells and surrounding observation wells will be gauged by electronic pressure transducers[1]. The transducers should be programmed to record water level data on a linear time scale with the maximum time interval of 2 seconds. Attachment 3 should be used to record field data during the step-drawdown pumping tests.

72-Hour Constant-Rate Aquifer Pumping Test

An electric submersible pump should be used for the constant rate test. Therefore, a reliable and 'clean' source of electrical power should be identified and a temporary electrical outlet should be installed in the immediate vicinity of the pumping wells.

The pump should be installed within the pumping well at the mid-screen interval (approximately 40 feet bgs in the intermediate well, and 75 feet bgs in the deep well). The pump must be equipped with a check valve to prevent back flow. Discharge from the pump should be controlled by means of a throttling valve and routed to a temporary holding tank. The holding tank should be sized to contain the entire discharge from a 24-hour period, and placed within a temporary secondary containment structure. Arrangements should be made with Shaw Group to empty the contents of the tank at regular intervals throughout the duration of the test.

Prior to the commencement of the constant rate aquifer pumping tests, electronic pressure transducers will be placed in each observation and pumping well to measure and record antecedent water level fluctuations for a period of 24 hours. The transducers should be

[1] Non-programmable pressure transducers may be used with a data logger, or multiple programmable transducers may be time-synchronized. The latter is preferable due to the absence of surface cables. Transducer ranges (i.e. 0 to 5 psi, 0 to 10 psi, etc) should be selected to reflect the anticipated water level fluctuations.

programmed to record water level data on a logarithmic time scale with the maximum time interval of 5 minutes (the minimum time interval should be automatically determined by the datalogger, but should not exceed 0.5 seconds). Data loggers should be downloaded to a laptop computer every 6 hours, **taking extreme care not to interrupt the data logging activity**. Barometric pressure readings, background water levels and rainfall will be monitored throughout the tests. Groundwater discharge must be measured and recorded every 15 minutes and adjusted as necessary to maintain a constant rate. **Attachment 4** should be used to record field data during the constant rate pumping tests.

Following completion of each test, water level recovery will be monitored for a period of at least 12 hours.

A.4.9 Gamma Logging

A subcontractor will be retained to conduct natural gamma logging of existing and newly installed deep monitoring wells. This information will be used in order to confirm the characterization of the lithology at Site 88. The geophysical logs will be compared with boring log descriptions completed by Baker Environmental in the Focused RI (1988).

The geophysical logging contractor will conduct natural gamma logging of thirteen (13) monitoring wells. The subcontractor shall:

- Provide daily logs of site activities that includes date and site location, logger's name and affiliation, model and serial numbers of all major equipment used, well ID and construction information, time that logging began and ended on a well, instrument settings and sensitivity, total linear feet of logging per well, number of hours on-site, and periods of down-time as a result of mechanical breakdown, weather, or other reasons.
- Provide natural gamma continuous-recording logging equipment and all necessary support equipment.
- The logging interval for each well shall range from approximately ground surface down to the bottom of the well (ranging from 85 feet to 150 feet bgs).
- Record logs in digital and analog format. Provide copies of the logs in graphic form.
- Select vertical scale units for the log commensurate with the purpose of the log (suggested scale is 1 inch = 10 feet).
- Set detector sensitivity at the highest level that produces no more than 10% of the total log showing off-scale deflection.
- Record scales, calibration and standardization, and other pertinent data on each log. Pertinent data recorded on the log header will include: the well ID; date; location; total depth; instrument settings and sensitivity; vertical scale; and logger's name and affiliation. This information will be provided with all three copies of the logs submitted to CH2M HILL.
- Record a duplicate (repeat) section of each log equal to 20 percent of total logged depth for each well. The duplicate section will be selected by CH2M HILL.

A.4.10 Land Surveying Procedures

Each soil and groundwater sample location will be surveyed by a North Carolina-licensed land surveyor. The locations will be referenced both horizontally and vertically to permanent land monuments or a grid system. The survey controls will be tied to a benchmark and the National Geodetic Vertical Datum (NGVD) of 1929. Ground surface and top of casing vertical control will be to the nearest 0.01 foot, and the horizontal control will be to the nearest 0.10 foot. The top of casing will be notched or otherwise marked to identify a constant measuring point for measuring depths to groundwater to determine groundwater elevations.

A.4.11 Quality Assurance/Quality Control Samples

Trip blanks, field blanks, equipment blanks, duplicate samples, and matrix spike/matrix spike duplicate (MS/MSD) samples will be collected during the RI and submitted for laboratory analysis. **Table A.4-2** describes each QA/QC sample and the required frequency of collection:

TABLE A.4-2
QA/QC Samples
Field Sampling Plan, Site 88, MCB Camp Lejeune

Sample Type	Description	Frequency	Analytes
Trip Blank	Designed to detect contamination of environmental samples during transport from the field to the laboratory. A trip blank is a VOC sample bottle filled with laboratory analyte-free water, transported to the site, handled like a sample, and returned to the laboratory for analysis. Trip blanks must not be opened in the field.	One per every cooler of soil and water samples sent to the laboratory for VOC analysis	VOCs only
Field Blank	Designed to detect contamination in the decontamination water. A field blank is decontamination water collected directly in the sample bottle. It shall be handled like a sample and transported to the laboratory for analysis.	One field blank from each source of decontamination water for each sampling event, where a sampling event is defined as one week	All laboratory analyses requested for the environmental samples collected at the site for that week
Equipment Blank	Designed to detect contamination of environmental samples caused by contamination of sampling equipment. An equipment blank is analyte-free water that is poured into or pumped through the sampling device, transferred to a sample bottle, and transported to the laboratory for analysis.	One per each day of sampling	All laboratory analyses requested for environmental samples collected at the site on that day
Field Duplicate	Designed to check precision of data in the laboratory. A field duplicate is a sample collected in addition to the native	10%	Same parameters as native sample

TABLE A.4-2
QA/QC Samples
Field Sampling Plan, Site 88, MCB Camp Lejeune

Sample Type	Description	Frequency	Analytes
	sample at the same sampling location during the same sampling event.		
MS/MSD	Designed to evaluate potential matrix interferences, accuracy, and precision. Three aliquots of a single sample – one native and two spiked with the same concentration of matrix spike compounds – are analyzed.	5%	Same parameters as native sample

A.4.12 Analytical Plan

Samples will be collected, handled, and analyzed in accordance with EPA guidelines. All field activities will be conducted in modified Level D PPE as detailed in the site-specific *Health and Safety Plan* (Appendix C).

Field Analyses

During drilling and sampling activities, the breathing zone will be monitored for potential health hazards to personnel performing these activities. This work will consist of monitoring the breathing zone for combustible gases using a combustible gas indicator (CGI), and monitoring VOCs and selected airborne organics using an FID. Both monitoring activities will be performed at the beginning of each task and at intervals as specified in the *Health and Safety Plan.*

During permanent monitoring well development and purging, water quality will be monitored for pH, temperature, specific conductance, and turbidity. The procedures for conducting these measurements are described in Sections A.6.4 and A.6.5, respectively.

Groundwater samples will also be analyzed for NAIPs in the field and in a fixed-base laboratory. Natural attenuation parameters that will be analyzed in the field are summarized in Table A.4-3.

TABLE A.4-3
Natural attenuation parameters to be measured in the field

Parameter	Method
Dissolved Oxygen	HACH Test Kit
Ferrous Iron	HACH Test Kit

TABLE A.4-3
Natural attenuation parameters to be measured in the field

Parameter	Method
Alkalinity	HACH Test Kit
CO_2	HACH Test Kit

Laboratory Analyses

Table 4-1 in the Work Plan summarizes the location and number of samples that will be submitted for laboratory analysis of chemical and geotechnical parameters. QA/QC samples will be collected at the frequency specified in **Table A.4-2**. In addition, representative IDW samples will be collected and analyzed for reactivity, ignitability, corrosivity, and TCLP parameters.

Detailed information regarding specific analytical methods, preservatives, sample container requirements, and holding times are discussed in Section A.7 of the *Field Sampling Plan*.

A.5 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including QA/QC samples, will be designated with a unique number. The number will serve to identify the investigation, the site, the sample media, sampling location, the depth (soil) or round (groundwater) of sample, and QA/QC qualifiers.

The sample designation format is as follows:

Site#-Media/Station# or QA/QC-Depth/Round

An explanation of each of these identifiers is given below.

Site#: This investigation includes Site 88 under the Installation Restoration Program. Therefore, the prefix "IR88" will be used

Media:

MW = Monitoring Well Boring
GW = Groundwater
IS = In-Situ Sampled Soil Boring

Station#: Each soil test boring or monitoring well will be identified with a unique identification number. Numbering will begin with 64, as 63 was the last number used during the Supplemental Investigation.

QA/QC:

FB = Field Blank
D = Duplicate Sample (following sample type/number)
TB = Trip Blank
ER = Equipment Rinsate
MS/MSD = Matrix Spike/Matrix Spike Duplicate

Depth/Round Depth indicators will be used for soil samples.

The number will reference the depth interval of the sample. For example:

01 = 6 to 8 feet below ground surface
02 = 8 to 10 feet below ground surface
03 = 10 to 12 feet below ground surface, etc.

Under this sample designation format, the sample designation IR88-IS64-04D refers to:

IR88-IS64D-04	Site 88
IR88-IS64D-04	In-Situ Sampled Soil Boring
IR88-IS64D-04	Boring #64, duplicate
IR88-IS64D-04	Sample depth interval 12 to 14 feet bgs

The sample designation SIA-ERSB01-02 refers to:

IR88-ERSB01-02	Site 88
IR88-ERSB01-02	Equipment Rinsate
IR88-ERSB01-02	Rinsate 01 taken from soil sampling equipment
IR88-ERSB01-02	Year (2002)

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

A.6 Sampling Equipment and Procedures

Field activities for the remedial investigation at Site 88 include drilling, monitoring well installation and development, and soil and groundwater sampling. Each activity is described in more detail in the following sections.

A.6.1 Soil Borings

Soil borings will be drilled using DPT, HSA, and Rotosonic drilling methods. Soil samples will be collected from the deepest soil boring of each cluster for lithologic description, field analysis, and/or laboratory analysis. After all of the required samples have been collected from a soil boring, the borehole will be abandoned or a permanent groundwater monitoring well will be installed in the borehole. Soil borings for permanent groundwater monitoring wells will be drilled using HSA or Rotosonic drilling methods. If a soil boring is abandoned, soil boring abandonment procedures outlined in this Work Plan will be followed. If a groundwater monitoring well is to be installed in the soil boring, well installation procedures outlined in this Work Plan will be followed.

Contractor drilling equipment will be cleaned in accordance with decontamination procedures specified in this Work Plan before being brought onsite. No visible evidence of contamination will be permitted on contractor equipment entering the sites. Sampling equipment and well materials will be cleaned in accordance with decontamination procedures specified in this Work Plan before drilling each soil boring and monitoring well. Only Teflon® tape or vegetable oil will be used to lubricate auger joints and other equipment joints or tools. Grease and pipe dope will not be used. Soil cuttings will be placed in 55-gallon drums and handled as investigation-derived waste (IDW) in accordance with the waste management procedures specified in this Work Plan.

The HSA drilling method uses a standard split-spoon soil sampler to collect samples. The standard split-spoon soil sampler is pushed directly into the ground to the desired depth, in accordance with ASTM D-1586, *Standard Method for Penetration Test and Split-Barrel Sampling of Soils*. Soil samples are obtained by retracting the soil sampler from the borehole and detaching the split-spoon sampler from the rods. The split barrel is opened, and soil is removed and placed into a sample container. Each split spoon will be 2 feet in length. Split spoon samples will be taken at five foot intervals.

The DPT drilling method uses either an open core barrel or piston sampling device. The core barrel is used in much the same way as the previously described split-spoon sampler, although the sample chamber contains a disposable PVC or acetate liner. The piston sampler consists of a DPT core barrel equipped with a releasable drive point that seals the sample chamber closed during the initial sampling push

Upon arrival at the desired depth, the drive point can be remotely released and the push continued. During the subsequent push, the released drive point rises freely up the inside of the sample chamber as the soil core displaces it. The push rods and sample chamber are

retrieved from the borehole, and the liner containing the sample is removed. The liner is cut open and the soil sample is placed in a sample container. Downhole sampling equipment is decontaminated, and a new liner is placed in the sample chamber to collect the next sample. Samplers will be 4 feet in length and will be used for continuous sampling of the borehole.

The Rotosonic drilling method produces a nominal 3.5-inch diameter soil core. The rotosonic system consists of an inner nominal 4-inch diameter casing and several successively larger outer casings (nominally 6, 8, 9, 10, and 12-inch diameter). Continuous soil cores of up to 10 feet in length will be collected using this drilling method. See Section A.4.3 for a discussion of the use of temporary isolation casings while drilling intermediate and deep boreholes.

In each case, immediately upon opening the core barrel, the entire soil core will be quickly screened for organic vapors using a FID. One-inch long portions of the soil cores will be collected at 2.5-foot intervals for VOC headspace measurements. Samples will be placed in a new re-sealable plastic bag and placed in the sun for a minimum of 15 minutes. The FID probe will be inserted into the bag for the headspace measurement, and the results will be recorded in the field logbook and on the soil boring log.

It is possible that drilling refusal will be encountered during the subsurface investigation. If so, the borehole location will be moved to a nearby location (cleared for utilities) determined in the field.

Field descriptions will be recorded on boring logs (**Attachment 1**) and in the field logbook. Soil and rock sample descriptions are prepared as described in Section A.6.1.1. Procedures for soil sampling are described in Sections A.6.1.2 and A.6.1.3.

Soil Sampling Procedures For Lithologic Characterization

Soil samples will be collected for lithologic characterization continuously from ground surface to the total depth of the soil boring. The physical characteristics of each soil sample will be described and recorded by the CH2M HILL field geologist or hydrogeologist. An example soil boring log is provided as Attachment 1. The following information will be recorded on the soil boring log for each soil sample.

- Soil boring identification number
- Name of the drilling company and the driller
- Name of the FTL
- Drilling method
- Sampling method
- Sample depth
- SPT blow counts
- Soil boring location and elevation (general description and survey data)
- Physical or chemical analyses requested

Soil types encountered will be classified according to ASTM Standard D2488-69, "Description of Soils (Visual-Manual Procedure)." The soil boring logs will show the depths at which each distinct stratum is encountered. Soil descriptions will comply with the Unified Soil Classification System, including grain-size classifications (i.e., fine, medium, and coarse sand and gravel); the use of the percentage terms "trace" (1 to 10 percent),

"little" (11 to 20 percent), "some" (21 to 35 percent), and "and" (36 to 50 percent); and the group symbols.

Soil Sampling Procedures for Physical Parameters

It is anticipated that two to three samples from the deepest boring in each cluster will be submitted for laboratory physical analysis. Two samples will be taken if the deepest boring is in the intermediate aquifer, and three samples will be taken if the deepest boring is in the deep aquifer. Shelby tube soil samples will be collected from intervals of 20 to 22 feet bgs (silty aquitard), 45 to 47 feet bgs (fine sand aquifer), and 70 to 72 feet bgs (silty fine sand aquitard) in accordance with ASTM standard procedure D-1587.

Following retrieval, Shelby tubes will be labeled (indicating vertical orientation), sealed with molten wax, and maintained upright until transported to the geotechnical testing facility.

Soil Sampling Procedures for Analytical Parameters

Surface soil samples may be analyzed for VOCs. VOC samples will be collected in accordance with Method 5035/8260. The following sampling protocol will be employed whenever soil samples are collected for VOCs in soils at Site 88. Because of the short hold times in effect for EnCore© samplers, CH2M HILL has elected to use the Syringe method with in-field preservation. The subcontracted analytical laboratory will supply the specific sampling containers and sampling tools required.

Equipment

Once the soil/sediment has been obtained, syringes and pre-prepared 40 mL vials may be used for sub-sampling collection.

Sampling Methodology - Low Concentrations

When total VOC concentrations in the soil/sediment are expected to be less than 200 µg/kg, the samples may be collected directly with the syringe. When using the syringes, the sample must be placed in the sample container (40 ml pre-prepared vial) immediately to reduce volatilization losses. The 40 ml vials should contain 10 ml of organic free water for an un-preserved sample or approximately 10 ml of organic free water and a preservative. The 40 ml vials will be prepared and weighed by the laboratory.

NOTE: After collection, the sample must immediately be stored in an ice chest and cooled.

Soil/sediment samples may be prepared for shipping and analysis as follows.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40 ml pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seals on the container, place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Special Techniques and Considerations

Effervescence

If low concentration samples effervesce from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved as needed, or all samples must be collected un-preserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence (rapid formation of bubbles) then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note that the amount of organic free water placed into the vials will have to be accurately measured.

Holding Times

Sample holding times are specified in **Table A-7-1**. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

Percent Moisture

Samplers must ensure that the laboratory has sufficient material to determine percent moisture in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent moisture determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz) for percent moisture determination will be required.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

A.6.2 Groundwater Sampling

DPT Borings

Discrete groundwater samples will be collected from the DPT soil borings using Teflon® tubing (or other appropriate tubing) and a peristaltic pump. Discrete groundwater sampling procedures for DPT soil borings are similar to the groundwater sampling procedures for

monitoring wells that are discussed below. Discrete groundwater samples will be sent to an on site mobile laboratory for analysis of VOCs.

Groundwater Monitoring Wells

Monitoring wells will be purged to remove standing water in the wells before groundwater samples are collected. Purge water will be containerized and transported to the Lot 203 treatment system for disposal.

Purging Procedures

The following groundwater purging procedure will be used.

1. For each well sampled, information on location, diameter(s), depth, and screened interval(s) will be recorded on the groundwater purging and sampling forms (**Attachment 5**).
2. Either a pump or bailer will be used to purge the well. A bailer will be used when the well does not yield sufficient water for pumping; otherwise, a pump is preferred.
3. Instruments will be calibrated according to manufacturers' instructions.
4. The well number, site, condition, and date will be recorded in the field logbook.
5. Plastic sheeting will be placed on the ground, and the well will be unlocked and opened.
6. Water level measurements will be collected, and the total well depth will be measured. The water level will be measured at the highest point on the inner PVC well casing or point to the nearest 0.01 foot.
7. The initial pH, specific conductance, temperature, and turbidity will be measured and recorded on the groundwater purging and sampling form.
8. The volume (in gallons) of water in the well casing will be calculated using the following method:

   $(\Pi r^2 h)\ 7.48 = \text{gallons}$
   where: $\Pi = 3.142$
   r = radius of the well pipe in feet
   h = linear feet of water in well
   7.48 = gallons per cubic foot of water

9. The volume of water in a typical 2-inch-diameter well casing will be calculated using the following method:

   gallons/feet x __ (linear feet of water) = total gallons

10. In productive wells, the well purging end point will be determined using field measurements of pH, specific conductance, temperature, and turbidity. A minimum of three to five well volumes will be removed prior to sampling. For non-productive wells, the well will be bailed dry and allowed to recover before sampling.
11. Field parameters will be measured at least once for each well volume of water removed while the well is being purged.

12. Well purging will be completed when field parameters have stabilized. With respect to the volume of groundwater, adequate well purging is normally achieved when the column of water in the well is free of visible sediment. A minimum of three well volumes will be removed from the well before groundwater samples are collected. With respect to groundwater chemistry, adequate purging is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized and the turbidity has either stabilized or is below 10 NTUs. Ten NTUs is twice the primary drinking water standard and is the goal for most groundwater sampling objectives. Stabilization occurs when pH measurements remain constant within 0.1 SU, specific conductance varies no more than 10 percent, and the temperature is constant for three consecutive readings. If sufficient water is not present to yield required purge volumes, the well will be purged to dryness.

13. Groundwater samples will be collected when purging has been completed. The elapsed time between completion of well purging and groundwater sample collection will be minimized. Typically, the sample will be collected immediately after the well has been purged, but this will depend on well recovery.

Sampling Procedures

The following procedure will be used to collect groundwater samples from all permanently installed monitoring wells at Site 88:

1. Before samples are collected, the well will be purged as described above. This process includes placing plastic sheeting around the well, recording pertinent information in the field logbook, and collecting water level measurements. Additional information for sampling includes the sample identification number and the time of sampling.

2. As necessary, sampling equipment will be cleaned and decontaminated prior to sampling.

3. The person performing the sampling will wear clean, unused PVC or latex gloves. Gloves will be changed before each sample is collected.

4. If a bailer is to be used, it will be removed from either its protective covering or the well casing and attached, if necessary, to a cord that is compatible with the analytes and long enough to reach the bottom of the well. If a bladder pump is to be used, air, sample, and lifting lines will be attached to the pump. The lifting lines will bear the weight of the pump; the air and sample lines will be attached to the lifting lines at 10-foot intervals. If a peristaltic pump is to be used, new lines will be attached to the pump at each new sampling location.

5. The pump, bailer, or line will be lowered to the interval from which the sample is to be collected. If a bailer is used, it will be allowed to fill with a minimum of surface disturbance to prevent sample water aeration. When the bailer is raised, the bailer cord will not be allowed to touch the ground. For the bladder pump, the air lines from a regulated compressed gas source will be connected to a control box, and a power supply will be connected to the pump (if required). Air flow will be started and adjusted with the throttle knob on the control box. Discharge and refill knobs on the control box will

be used to control the cycling rate of flow in the bladder. Equal length cycles are generally desired, but individual well conditions will be the controlling factor.

6. The cap will be removed from the sample bottle, and the bottle will be tilted slightly.
7. The sample will be poured slowly from the bailer line or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing.
8. Adequate space will be left in the bottle to allow for expansion, except for volatile organic analyte (VOA) vials, which will be filled to overflowing and capped.
9. The bottle will be capped, then labeled clearly and carefully. Label information will include laboratory, project name and number, sample ID, station ID, preservative, analysis, sampler's initials, date, and time.
10. Samples will be placed in appropriate containers and ,if necessary, packed with ice in coolers as soon as practical.
11. If the sampler (bailer) is dedicated, it will be returned to the well, and the well will be capped and locked. Non-dedicated samplers will be cleaned and decontaminated after use.

A.6.3 Decontamination

Decontamination procedures for drilling equipment, well construction material, and sampling equipment are described below. The decontamination area will be a temporary structure large enough to contain any drilling equipment, well materials, and the rear of the drilling rig. The area will be designed to collect, contain, and drain all fluids to a central point so that the collected fluids can be pumped and drummed. The decontamination area will be constructed of materials that preclude puncturing or leakage caused by decontamination activities. Racks will be provided to hold all equipment and well materials off the ground during decontamination. All equipment and well materials will remain racked and covered when not in use. All decontaminated well materials will be handled only with new, unused surgical gloves to avoid contamination prior to installation.

Drilling Equipment and Well Construction Material

Before mobilizing to the site, the drilling equipment and sampling tools will be cleaned with a high-pressure hot-water power washer or steam jenny, or hand washed with a brush using detergent to remove oil, grease, and hydraulic fluid from the exterior of the unit. The detergent does not have to be laboratory grade detergent. Degreasers will not be used. All drilling equipment and sampling tools will be decontaminated prior to each DPT boring and monitoring well installation. All soil and groundwater sampling equipment shall be decontaminated prior to each sample being collected within the same borehole. All augers, water storage tanks, pumps, piping, drill pipe, and similar equipment will be flushed with potable water followed by cleaning with a hot-water pressure washer.

Decontamination of all equipment, tools, and well materials will consist of hot-water pressure washing to remove all visible evidence of soil, encrustations, or films. Well

materials, augers, drill rods, and split-spoon samplers will be rinsed with de-ionized water after pressure washing and prior to use.

Sampling Equipment

The stainless-steel sampling equipment (such as split-spoon samplers) will be decontaminated to prevent the introduction of contaminants into the boring. This decontamination will be conducted according to the following procedure:

1. Wash equipment with a laboratory detergent (i.e., alconox, liquinox, or the equivalent) and hot water, using a brush to remove any particulate matter or surface film.
2. Rinse equipment thoroughly with tap water.
3. Rinse equipment thoroughly with de-ionized or organic-free water.
4. Rinse equipment twice with pesticide-grade isopropanol and allow to air dry.
5. Rinse equipment twice with ASTM Type II Water (ASTM 01193-77).
6. Wrap equipment in aluminum foil (dull side in) to prevent contamination during storage or transport to the field. Larger pieces of equipment, such as augers, may be wrapped in new visqueen or equivalent.

Teflon® and glass field sampling equipment decontamination will be conducted according to the following procedure:

1. Wash equipment with a laboratory detergent (i.e., alconox, liquinox, or the equivalent) and hot water, using a brush to remove any particulate matter or surface film.
2. Rinse equipment thoroughly with tap water.
3. Rinse equipment with 10 percent nitric acid solution.
4. Rinse equipment thoroughly with tap water.
5. Rinse equipment thoroughly with de-ionized water or organic-free water.
6. Rinse equipment twice with pesticide-grade isopropanol and allow to air dry.
7. Rinse equipment twice with ASTM Type II Water (ASTM 01193-77).
8. Wrap equipment in aluminum foil (dull side in) to prevent contamination during storage or transport to the field.

Well sounders or tapes (used to measure groundwater levels) and submersible pumps and hoses (used to purge monitoring wells) will be decontaminated according to the following procedure:

1. Wash equipment with a laboratory detergent and tap water, running solutions through the pumps and pump hoses.
2. Rinse equipment thoroughly with tap water.
3. Rinse equipment thoroughly with de-ionized or organic-free water.

4. Place the equipment in a polyethylene bag or wrap it with polyethylene film to prevent contamination during storage or transit.

Water sampling, water level measuring, and sample preparation equipment that comes onsite will be cleaned prior to and after each use. During cleaning and decontamination operations, the substitution of a higher grade water for tap water is permitted and does not have to be noted as a variation. Equipment decontamination will be conducted by personnel wearing Level D PPE in accordance with the site-specific *Health and Safety Plan* (Appendix C).

A.6.4 Investigation-Derived Waste (IDW) Handling

Wastes generated during the investigation of potentially contaminated sites are classified as IDW and will be containerized. Wastes will be placed in 55-gallon drums that meet the packaging requirements of 49 *Code of Federal Regulations* (CFR) 173 and staged on wooden pallets. Soil, water, and PPE will be drummed separately. The FTL is responsible for labeling each IDW drum with the boring number, date, contents, and contact information.

All IDW will be characterized prior to completion of the field project. For this investigation, the IDW (soil and water) will be tested for reactivity, corrosivity, ignitability, and toxicity characteristic leaching procedure (TCLP) VOCs, and metals (EPA Method 1311).

IDW will be managed and disposed of in accordance with federal, state, and local environmental rules and regulations. The drums containing IDW soil will be handled as follows:

- If the soil is not characterized as hazardous waste, it will be disposed of in the MCB Camp Lejeune landfill.
- If the soil is characterized as hazardous waste, it will be disposed of at a permitted off-site facility.

The drums containing IDW water will be transported to the Lot 203 treatment system for disposal. Other IDW will be managed as solid waste and disposed of at the MCB Camp Lejeune landfill. All IDW disposal will be coordinated with Shaw Group.

A.7 Sample Handling and Analysis

A.7.1 Sample Preservation and Handling

Sample preservation occurs in the field immediately after collection. The containers supplied by the laboratory will contain applicable preservative. This will protect field personnel from transporting, handling, and measuring concentrated acids and bases. QA/QC samples, with the exception of trip blanks, will be collected in the same containers with preservatives as the field samples. A list of preservatives and holding times for each type of analysis are included in **Table A-7-1.**

TABLE A-7-1
Sample Containers, Preservation, and Holding Times
Field Sampling Plan, Site 88, MCB Camp Lejeune

Analysis	Matrix	Method	Container	Preservation	Maximum Hold Time
VOCs	Aqueous	SW846 8260B	3 x 40 mL G-TLC	HCl to pH<2, Cool to 4°C	14 days
	Solid	SW846 5035/ 8260B	3 x 40 mL VOA	Methanol, sodium bisulfate, Cool to 4°C	7 days
Metals	Aqueous	SW 846 6010B and 7000 Series	1 x 0.5L HDPE	HNO_3 to pH<2, Cool to 4°C	6 months
	Solid	SW 846 6010B and 7000 Series	1 x 8 oz. G-TLC	Cool to 4°C	6 months

VOA = Volatile organic analyte

A.G. = amber glass

G-TLC = Clear glass container with a Teflon-lined cap

HDPE = High-density polyethylene container

Samples collected during the field activities will be shipped via an overnight courier to the analytical laboratory. A cooler of suitable strength for packaging and shipping of samples will be used and will be manifested to meet U.S. Department of Transportation regulations (dangerous goods, etc.). The bottom and sides of each cooler will be lined with bubble wrap or other cushioning material. Each sample jar or bottle will also be individually wrapped in bubble wrap to prevent breakage. All samples will be kept upright in the cooler. Once the samples are in the cooler, any voids will be filled with additional packaging material. Ice will be double-bagged in re-sealable bags and placed in the cooler with the samples. A sufficient amount of ice will be added to the coolers to ensure they arrive at the laboratory at a temperature of 4°C. The COC record shall be placed in a watertight plastic bag and taped to the inside lid of the cooler. The cooler will be secured with strapping tape and custody

seals will be affixed to the front and back of the cooler. The custody seals will be covered with wide, clear adhesive tape.

A.7.2 Chain-of-Custody

A chain-of-custody (COC) form will be prepared for each shipment of samples to the laboratory. Information recorded will include, at a minimum, site name, sampler name(s), date and time of sample collection, identification code unique to each sample, number of containers with the same sample code, analyses requested for each sample (including the analytical method numbers), and signature blocks for each individual who has custody for the sample(s). All blank spaces (except for signature blocks) should be crossed out and initialed prior to shipment to the lab.

Upon receipt of samples at the laboratory, all samples will proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and other pertinent information to the analysis. If no discrepancies are identified, the sample COC record will be signed, and the samples will be assigned a unique laboratory identification number by the laboratory for tracking and filing. The laboratory QA system and the use of an internal COC procedure will ensure that the samples are appropriately tracked from storage through the laboratory until the analytical process is complete.

Additional information regarding COC forms is contained in Section 6 of the *Quality Assurance Project Plan* (Appendix B). **Attachment 6** provides an example COC form.

A.7.3 Field Logbook

A daily field log will be maintained, in a bound notebook. In this log will be recorded all the onsite field activities in real time, including the names of individuals onsite and sampling information, such as sample location, sample number, number of bottles collected, etc. Recorded information will include, as a minimum, the following:

- Project name and number
- Individuals onsite
- Sample locations (well and/or boring number) and depths
- Current date, pertinent times (in military time), condition of the well, and ambient weather conditions
- Sample numbers, number/type of containers, sample time and date
- Analyses requested and laboratory assignments
- Sampler's name and signature
- Results of FID measurements
- Type of sample collected
- Other notes and information, as required

Notes will be written on sequentially numbered pages with indelible ink. At the end of each day, any unused space at the bottom of the last page will be "crossed" out, initialed, and dated by the FTL.

A.7.4 Corrections to Documentation

Corrections that are required in field logbooks or on any field forms must be done by lining through incorrect entries with a single line and initialing and dating the strikeout.

A.8 Site Management

CH2M HILL is responsible for the following activities during the remedial investigation at Site 88:

- Task order management
- Quality assurance/quality control
- Worker safety and health
- Planning
- Data evaluation and reporting
- Subcontractor supervision

CH2M HILL personnel responsible for the above aspects of the project are presented in Table A-8-1.

TABLE A-8-1
CH2M HILL Project Responsibilities
Field Sampling Plan, Site 88, MCB Camp Lejeune

Project Position	Responsible Personnel	Contact Information
Project Manager	Tegwyn Williams	(704) 329-0073 x227
Activity Manager	Christopher Bozzini	(704) 329-0073 x291
Senior Consultant/Review Team Leader	Sam Shannon	(334) 271-1444 x322
Project Chemist	Ann West	(703) 471-1441 x4643
Lead Data Manager	Jamie Culbreth	(757) 460-3734 x39
Project Hydrogeologist	Tegwyn Williams	(704) 329-0073 x227
Field Team Leader	Jeremy Vaughan	(704) 329-0073 x298
		(704) 236-8363 mobile
Site Safety Coordinator	Jeremy Vaughan	(704) 329-0073 x298
		(704) 236-8363 mobile
Health and Safety Manager	Mike Goldman	(770) 604-9095 x396

In addition to the above personnel, other Field Team Members will be used on the project. Field Team Members will be responsible for the collection of samples and the performance of field measurements under the supervision of the FTL in accordance with the procedures set forth in the RI Work Plan, Quality Assurance Project Plan, and Health and Safety Plan.

Subcontractors will be used for the RI activities listed below:

- Utility location
- Video survey of the stormwater and wastewater sewer lines
- Drilling and groundwater monitoring well installation
- Natural gamma logging of existing and newly installed deep groundwater monitoring wells
- Analytical laboratory services
- Geotechnical laboratory services
- Transportation and disposal of investigation-derived waste (IDW)
- Survey of the location and elevation of soil borings, groundwater monitoring wells, and other sampling locations

The project organizational structure is presented in **Figure 6-1** of the Work Plan.

Attachment 1

Sample Boring Log

Attachment 1

CH2MHILL

Boring Number:

Sheet: 1 of 1

Client:
Project:
Location:
Project Number:

Driller:
Drilling Method:
Sampling Method:
Logged by:
Start/Finish Date:

Depth (ft)	Sample Information: Sample	Sample Information: Sample Type	Sample Information: Recovery (%)	Sample Information: SPT (6"-6"-6")	Soil Log	Soil Description	Depth / Elev (ft)	Comments
0						Ground Surface	0 / 0	
5								
10								
15								
20								

FINAL

Attachment 2

Well Completion Form

Attachment 2

CH2MHILL

PROJECT NUMBER	WELL NUMBER SHEET OF

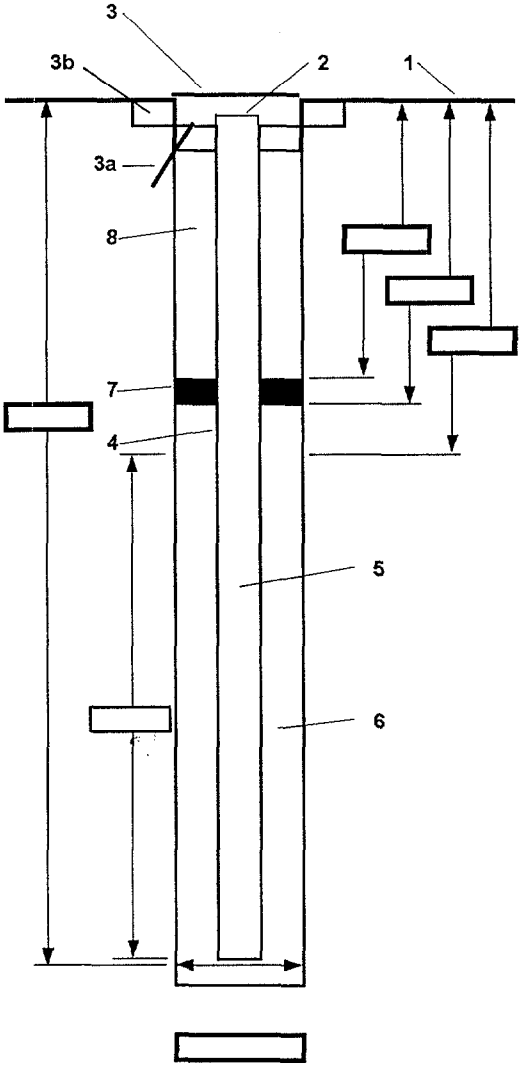
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____

3- Wellhead protection cover type _____
a) drain tube? _____
b) concrete pad dimensions _____

4- Dia./type of well casing _____

5- Type/slot size of screen _____

6- Type screen filter _____
a) Quantity used _____

7- Type of seal _____
a) Quantity used _____

8- Grout
a) Grout mix used _____
b) Method of placement _____
c) Vol. of well casing grout _____

Development method _____

Development time _____

Estimated purge volume _____

Comments:

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Attachment 3

Well Development Form

Attachment 3

CH2MHILL

Well Development Sheet

Project Site Name: _____ **Well ID:** _____

Project No: _____ **Contractor:** _____

Development data

	Time	pH SU	Cond. mS/cm	Temp. °C	Turbidity NTU	DO mg/L	ORP mV	Volume gallons
Date:								
Method:								
Pump setting:								
Well casing dia. (in.):								
Total well depth (TOC):								
Static water level (TOC):								
One purge volume (gals.):								
Start time:								
End time:								
Total dev. volume (gals.):								
Comments:								

Observations/Notes:

FINAL

Attachment 4

Aquifer Testing Data Sheet

AQUIFER TEST DATA

Owner: _____ Address: _____ County: _____ State: _____

Date: _____ Company performing test: _____ Measured by: _____

Well No.: _____ Distance from pumping well: _____ Type of test: _____ Test No.: _____

Measuring Equipment: _____

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date: _____ Time: _____	Static water level: _____ Feet	How Q measured: _____	
Pump off: Date: _____ Time: _____	Measuring point: _____	Depth of pump/airline: _____	
Duration of aquifer test: _____	Elevation of measuring point: _____	Previous pumping? Yes_____ No_____	
Pumping: _____ Recovery: _____		Duration: _____ End: _____	

Date	Clock Time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate	
		1											
		2											
		3											
		4											
		5											
		6											
		7											
		8											
		9											
		10											
		12											
		14											
		16											
		18											
		20											
		22											
		24											
		26											
		28											
		30											
		35											
		40											
		45											
		50											
		55											
		60											
		70											
		80											
		90											
		100											
		110											
		120											
		140											

AQUIFER TEST DATA

Owner: _____ Address: _____ County: _____ State: _____

Date: _____ Company performing test: _____ Measured by: _____

Well No.: _____ Distance from pumping well: _____ Type of test: _____ Test No.: _____

Measuring Equipment: _____

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date: _____ Time: _____	Static water level: _____ Feet	How Q measured: _____	
Pump off: Date: _____ Time: _____	Measuring point: _____	Depth of pump/airline: _____	
Duration of aquifer test: _____	Elevation of measuring point: _____	Previous pumping? Yes_____ No_____	
Pumping: _____ Recovery: _____		Duration: _____ End: _____	

Date	Clock Time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate	
		160											
		180											
		200											
		220											
		240											
		270											
		300											
		330											
		360											
		390											
		420											
		450											
		480											
		510											
		540											
		570											
		600											
		630											
		660											
		690											
		720											
		750											
		780											
		810											
		840											
		870											
		900											
		930											
		960											
		990											
		1020											
		1050											
		1080											

AQUIFER TEST DATA

Owner: _____ Address: _____ County: _____ State: _____

Date: _____ Company performing test: _____ Measured by: _____

Well No.: _____ Distance from pumping well: _____ Type of test: _____ Test No.: _____

Measuring Equipment: _____

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date: _____ Time: _____	Static water level: _____ Feet	How Q measured: _____	
Pump off: Date: _____ Time: _____	Measuring point: _____	Depth of pump/airline: _____	
Duration of aquifer test: _____	Elevation of measuring point: _____	Previous pumping? Yes_____ No_____	
Pumping: _____ Recovery: _____		Duration: _____ End: _____	

Date	Clock Time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
		1110												
		1140												
		1170												
		1200												
		1230												
		1260												
		1290												
		1320												
		1350												
		1380												
		1410												
		1440												
		1500												
		1560												
		1620												
		1680												
		1740												
		1800												
		1860												
		1920												
		1980												
		2040												
		2100												
		2160												
		2220												
		2280												
		2340												
		2400												
		2460												
		2520												
		2580												
		2640												
		2700												

AQUIFER TEST DATA

Owner: _____ Address: _____ County: _____ State: _____

Date: _____ Company performing test: _____ Measured by: _____

Well No.: _____ Distance from pumping well: _____ Type of test: _____ Test No.: _____

Measuring Equipment: _____

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date: _____ Time: _____	Static water level: _____ Feet	How Q measured: _____	
Pump off: Date: _____ Time: _____	Measuring point: _____	Depth of pump/airline: _____	
Duration of aquifer test: _____	Elevation of measuring point: _____	Previous pumping? Yes_____ No_____	
Pumping: _____ Recovery: _____		Duration: _____ End: _____	

Date	Clock Time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate	
		2760											
		2820											
		2880											
		2940											
		3000											
		3060											
		3120											
		3180											
		3240											
		3300											
		3360											
		3420											
		3480											
		3540											
		3600											
		3660											
		3720											
		3780											
		3840											
		3900											
		3960											
		4020											
		4080											
		4140											
		4200											
		4260											
		4320											

FINAL

Attachment 5

Purge and Sampling Sheet

Attachment 4

PROJECT NUMBER	PROJECT NAME

CH2MHILL

WELL PURGE AND SAMPLING FIELD SHEET

SITE:	DATE:
FIELD CREW:	WELL NUMBER:
WEATHER:	

PURGE VOLUME CALCULATION:

			CASING DIAMETER	GAL/FT OF CASING
WELL DEPTH (FT):				
DEPTH TO WATER (FT):	-		2 IN.	0.1632
WATER COLUMN (FT):	=	0	4 IN.	0.6528
GAL/FT OF CASING (from table at right):	x	0.1632	6 IN.	1.4688
CASING VOLUME (GALs):	=	0	8 IN.	2.611
NO. OF VOLUMES (min. 3):	x		10 IN.	4.0797
PURGE VOLUME (GAL):	=	0	12 IN.	5.8748

METHOD OF PURGING (circle one)

PUMP: SUB., CENT., PERIST. **OTHER:**

TIME ON:

FLOW RATE (gpm):

PUMP TIME (min):

VOL. PURGED (gals):

BAILER : TEFLON, SS ,OTHER:

BAILER VOL.. (gal) .25 / .33 / .75

REQUIRED PULLS:

VOL. PURGED (gals):

OTHER:

FIELD PARAMETER MEASUREMENTS Field Equipment Used: Horiba U-22

No.	Time	Volume	pH	Temperature	Conductivity	Turbidity	Other (DO; ORP)
1							
2							
3							
4							
5							
6							
7							
8							

OBSERVATIONS (circle as appropriate)

COLOR: CLEAR , AMBER , TAN , BROWN , GREY , MILKY WHITE , OTHER:

ODOR: NONE , LOW , MEDIUM , HIGH , VERY STRONG , H2S , FUEL LIKE , CHEMICAL ?, UNKNOWN

TURBIDITY: NONE , LOW , MEDIUM , HIGH , VERY TURBID. HEAVY SILTS

COMMENTS:

Please use back of sheet for sketching maps, well location notes, etc. **See back of sheet? Y / N**

SAMPLE DATA:

Sample ID Number	No. and Types of Containers	Parameters Analyzed	Laboratory	QA/QC sample? Y /N

SIGNED/SAMPLER: _____

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Attachment 6

Sample Chain of Custody

Attachment 5

Project #	Project Name						Number of Containers	Analyze For					Remarks
Samplers: (Signature)													
Sample #	Date	Time	Type	Comp	Grab	Sample Location							
Relinquished By:			Date:	Time:	Received By:		Relinquished By:				Date:	Time	Received By:
Relinquished By:			Date:	Time:	Received for Lab By:		Date	Time	Remarks				
Handling Instructions:													Turnaround Time:
Instructions													

Appendix B

FINAL

Site 88 Quality Assurance Project Plan

Operable Unit No. 15 (Site 88)

Marine Corps Base

Camp Lejeune, North Carolina

Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

Contract No. N62470-95-D-6007

CTO-0250

LANTDIV Clean II Program

July 2003

Prepared by

CH2MHILL

Table of Contents

Acronyms and Abbreviations

AM	Activity Manager
AOCs	Areas of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Above ground Storage Tank
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
bgs	Below Ground Surface
BMI	Battelle Memorial Institute
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPC	Chemicals of Potential Concern
COC	Contaminants of Potential Concern
CRDLs	Contract Required Detection Limits
CSF	Cancer Slope Factor
CTO	Contract Task Order
DCE	Dichloroethene
DEM	Division of Environmental Management
DNAPL	Dense Non-Aqueous Phase Liquids
DoN	Department of Navy
DOT	Department of Transportation
DPT	Direct Push Technology
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EMD	Environmental Management Divisions
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
Fm.	Formation
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
FSP	Field Sampling Plan
FWS	Fish and Wildlife Service
HA	Health Advisories
HASP	Health and Safety Plan
HI	Hazard Index

ICR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRP	Installation Restoration Program
kg	Kilogram
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCB	Marine Corps Base
MCLs	Maximum Contaminant Limits
MDLs	Method Detection Limits
mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
msl	Mean Sea Level
NAIPS	Natural Attenuation Indicator Parameters
NAVFAC	Naval Facilities Engineering Command
NC DENR	North Carolina Department of Environmental and Natural Resources
NCP	National Oil and Hazardous Substances Pollution and Contingency Plan
NCWQS	North Carolina Water Quality Standards
NFA	No Further Action
NWI	Nation Wetlands Inventory
OSHA	Occupational Safety and Health Administration
PCE	Tetrachloroethene
PAH	Polynuclear Aromatic Hydrocarbons
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goals
QA/QC	Quality Assurance/ Quality Control
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RABITT	Reductive Anaerobic Insitu Treatment Technology
RAGS	Risk Assessment Guidance for Superfund
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RRRS	Relative Risk Ranking System
SARA	Superfund Amendments and Reauthorization
SCS	Soil Conservation Service
SEAR	Surfactant Enhanced Aquifer Remediation
SI	Site Investigation

SPLP	Synthetic Precipitation Leaching Procedure
SSI	Supplemental Site Investigation
TAL	Total Analyte List
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
UCL	Upper Confidence Limit
UST	Underground Storage Tank
USC	United States Code
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
VOCs	Volatile Organic Compounds
WQS	Water Quality Standards

B.1 Introduction

This document has been prepared to serve as a *Quality Assurance Project Plan* (QAPP) for the remedial investigation at Operable Unit 15, Site 88 at the Marine Corps Base (MCB) Camp Lejeune in Onslow County, North Carolina. This QAPP describes the data quality objectives, specific quality assurance (QA) and quality control (QC) activities, and laboratory activities necessary to achieve the data quality objectives (DQOs) of the project.

Subcontractors will be furnished with a copy of the project-specific QAPP, and will be expected to adhere to the procedures specified herein.

B.2 Project Description

This section provides a brief history of Site 88 and previous environmental investigations. Section 1 of the Work Plan provides a detailed project description. Section 2 describes the site background and environmental setting.

B.2.1 Site History and Contaminants

Operable Unit 15, Site 88 is located within the boundaries of MCB Camp Lejeune on Post Lane Road, approximately 500 feet east of the intersection of Post Lane Road and Main Service Road. The site consists of the Base Dry Cleaning Facility (Building 25) and the surrounding grassy and paved areas (**Figure 2-3** in Work Plan). Site 88 is surrounding by troop housing and service buildings.

Beginning in the 1940s, Varsol™ was stored in underground storage tanks (USTs) located on the north side of Building 25. In the 1970s, Varsol™ was replaced by tetrachloroethene (PCE), which was stored in an aboveground storage tank (AST). PCE was reportedly stored in the AST from the 1970s until the mid-1980s. Facility employees reported that spent PCE was disposed of in floor drains. In March 1995, two self-contained dry cleaning machines were installed in Building 25, thus eliminating the need for bulk storage of PCE. The USTs were removed in November 1995.

B.2.2 Summary of Existing Site Data

Previous investigations at Site 88 include the focused remedial investigation (RI) performed by Baker Environmental in 1997, the Surfactant-Enhanced Aquifer Remediation (SEAR) pilot test performed in 1999, the Reductive Anaerobic In-Situ Treatment Technology (RABITT) pilot test performed in 2001, and the supplemental site investigation (SI) performed by CH2M HILL in 2002. The need for additional work is based on the findings presented in the September 2002 Draft Supplemental SI Report and the May 1998 Final Focused RI Report.

B.3 Project Organization and Responsibilities

This section identifies key project team members and lists the QA/QC responsibilities associated with each position; describes communication procedures that will be followed throughout the project; and summarizes the project schedule.

B.3.1 Project Team Members

The organizational structure (Work Plan, **Figure 6-1**) and responsibilities are designed to provide project QA/QC for the proposed investigation at Site 88. Each position is described in the following paragraphs.

Project Manager (PM)

The PM for this project is Tegwyn Williams. The PM is responsible for overall project activities, including cost control, schedule control, and technical quality. In addition, the PM develops the work plan and monitors task order activities to ensure compliance with project objectives and scope. The PM also communicates with MCB Camp Lejeune and other designated parties regarding project progress.

The PM has ultimate responsibility within the project team for producing deliverables that are technically adequate, satisfactory to the client, and cost-effective. To accomplish this, the PM develops an internal project review schedule, provides written instructions and frequent guidance to the project team, and monitors budgets and schedules. The PM will work with the project team to select an internal QA/QC review team, to coordinate review efforts, to address review comments, and to adjudicate technical issues.

Activity Manager (AM)

The AM for this project is Christopher Bozzini. The PM will be assisted by the AM. The primary objectives of the AM are to build and maintain the relationship with the client, to provide continuity across all CTOs/projects at MCB Camp Lejeune, and to manage the PM. The AM will provide overall guidance with regards to LANTDIV and Camp Lejeune and will serve as the alternate CH2M HILL contact. The AM has overall responsibility for Client satisfaction.

Senior Consultant and Review Team Leader (RTL)

The RTL for this project is Sam Shannon. The RTL is a company-wide resource with significant experience in the various technical aspects involved in a complex project. The RTL coordinates all internal QA/QC review for technical validity and adherence to both internal CH2M HILL policy and MCB criteria. The review team is responsible for evaluating the technical merit of the work planning documents before field activities begin, and reviewing all deliverables before submittal to MCB Camp Lejeune. The RTL assists the PM in selecting an internal QA/QC review team, coordinating review efforts, addressing review comments, and resolving technical issues.

Project Chemist (PC)

The project chemist for this project is Ann West. The PC assists with the preparation of the project work planning documents, provides a point of communication between the laboratory and the project team, supervises the analytical data quality evaluation, and participates in preparing deliverables to the client. The PC coordinates with the project team and the analytical laboratory during the field activities. The PC is also responsible for monitoring project-specific laboratory activities, including checking laboratory invoices and reports, and may audit the laboratory or field operations at the PM's direction. The PC also monitors field and laboratory activities to ensure that the QA/QC requirements described in this project-specific QAPP are met effectively.

Lead Data Manager (LDM)

The LDM for this project is Jamie Culbreth. The LDM is responsible for the structure, organization, format, implementation, and operation of the project database as described in the Work Plan. The lead data manager supervises the data management team and provides direction to the database manager.

Field Team Leader (FTL)

The FTL for this project is Dan Tomczak or Jeremy Vaughan. The FTL reports to the PM and is responsible for coordinating field efforts; providing and maintaining sampling equipment and materials; providing shipping and packing materials; and accurately completing the field logbook. The FTL will supervise the completion of all chain-of-custody (COC) records and the proper handling and shipping of samples. As the lead field representative, the FTL is also responsible for consistently implementing program QA/QC measures at the site and for performing field activities in accordance with approved work plans, policies, and field procedures.

Site Safety Coordinator (SSC)

The SSC for this project is Dan Tomczak or Jeremy Vaughan. The SSC develops and implements the project-specific *Health and Safety Plan* (Appendix C) in the field. The SSC will assist in conducting site briefings and perform all final safety checks. The SSC is responsible for stopping any investigation-related operation that threatens the health and safety of the field team or surrounding populace.

Health and Safety Manager (HSM)

The HSM for this project is Michael Goldman. The HSM reviews and approves the project-specific *Health and Safety Plan* as well as subcontractor *Health and Safety Plans*. The HSM serves as the point of contact for the SSC for any health- or safety-related issues, and may conduct project audits. The HSM is also responsible for investigating accidents should any occur during the course of the project.

Subcontractors

Subcontractors will be used for the remedial investigation activities at Site 88. The following services will be provided by subcontractors:

- Utility location
- Video survey of the stormwater and wastewater sewer lines
- Soil sampling using DPT
- Drilling and groundwater monitoring well installation
- Natural gamma logging of existing and newly installed deep groundwater monitoring wells
- Analytical laboratory services
- Geotechnical laboratory services
- Transportation and disposal of investigation-derived waste (IDW)
- Survey of the location and elevation of soil borings, groundwater monitoring wells, and other sampling locations

Procurement of subcontractors will be performed in accordance with the Navy Clean Contract Procurement Manual.

B.3.2 Project Communication

One of the most critical elements in performing any type of project is to establish and maintain lines of communication among all project personnel. At the beginning of the project or the start or end of major milestones, the PM will prepare written project instructions that will be distributed to all team members. These instructions will document project and task instructions, and each team member's responsibility in meeting the objectives, as well as a budget and schedule for successfully executing the work.

Before field activity begins, a project team meeting will be held to review the concept, assumptions, objectives of the field approach, and project objectives. Periodic meetings will be held to review data validity, technical evaluations, major decisions, and overall progress toward completing the project. Additionally, a team kickoff meeting will be held before work on each task is started. Senior personnel, including the RTL, will participate in the meetings to help focus the project approach and to define specific issues.

During the field investigation phase of projects, the field teams will meet daily to review the status of the project and to discuss technical and safety issues. When necessary, other meetings will be scheduled or the FTL will meet individually with field personnel or the subcontractors to resolve problems. During the field effort, the FTL will prepare a weekly report detailing project progress.

During the field effort, the FTL will be in regular telephone or face-to-face contact with the project team. When significant problems or decisions requiring additional authority occur, the FTL can immediately contact the PM for assistance. The PC, in consultation with the PM, will coordinate communication with the laboratory during sample collection, sample analysis, and data quality evaluation.

Daily and weekly reports, boring logs, QA reports, and other project information will be shared by the members of the project team as needed. All communications with MCB Camp Lejeune will be channeled through the PM for MCB Camp Lejeune, who will be informed of field activities being conducted on a daily basis.

B.3.3 Project Schedule

Figure 6-2 in the Work Plan presents the schedule for the remedial investigation at Site 88. At this time, it is anticipated that the field activities will begin in March, 2003, and that the final RI report will be delivered to MCB Camp Lejeune in October, 2003.

B.4 Quality Assurance Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the quality of data required from field and laboratory data collection activities to support decisions concerning risk and remediation. DQOs are established prior to data collection and describe what data are needed, why the data are needed, and how the data will be used to address the problems being investigated. DQOs help to ensure that all data collected are legally and scientifically defensible.

B.4.1 Background

The purpose of the RI is to address the remaining data gaps and to complete the identification and delineation of the releases at Site 88. The specific project objectives are as follows:

- More completely document the potential effects of solvent disposal into the wastewater conveyance system. This work will include video surveys of the stormwater and wastewater sewer lines associated with Building 25.
- Assess the horizontal and vertical extent of the chlorinated solvent release in soil and groundwater.
- Investigate the thickness, lateral continuity, and permeability of the lower confining unit for the shallow surficial aquifer beneath the site.
- Evaluate the hydraulic conductivity among the shallow, intermediate, and deep aquifers beneath Site 88.
- Demonstrate that biological degradation is the dominant physical process that is occurring in the shallow aquifer.
- Evaluate fate and transport of the chlorinated solvents within soil and groundwater.
- Prepare a Comprehensive Final RI Report summarizing the findings of the investigation.

B.4.2 Levels of Data Quality

Three categories of data will be collected as part of the field effort, and each category has a different level of supporting QA/QC documentation. Level 1 includes field monitoring activities, such as pH, conductivity, temperature, and turbidity. Level 2 includes the analyses for physical parameters such as percent moisture, porosity, permeability, and grain size distribution. Level 2 also includes the analyses associated with the characterization of the IDW samples. All other samples will be submitted to the laboratory for Level 3 analyses. For each QC level, the measures and methods to be used, as well as the applicable data package deliverables, are outlined below.

Level 1 – Field Surveys

Level 1 encompasses field monitoring or screening activities and does not require formal data package deliverables. Level 1 activities are focused on easily measured characteristics of a sample such as total organic vapors, pH, conductivity, temperature, and turbidity. The data generated from field surveys are used to make decisions about the execution of the investigation or to provide general sample screening before laboratory analysis.

Monitoring results, as well as pertinent data concerning the sampling event, will be documented in the field logbook. Level 1 documentation will consist of the following:

- Instrument identification
- Calibration information (standards used and results)
- Date and time of calibration and field measurements
- Field measurement results

The logbooks will be reviewed daily by the FTL for completeness and correctness. No additional documentation or data quality evaluation is required.

Level 2 – Physical Parameters and IDW Analyses

Level 2 includes the samples submitted to the laboratories for physical parameter testing and IDW characterization. Samples submitted for analysis under Level 2 will require the delivery of an analytical data package. Level 2 documentation will consist of the following:

- Case narrative
- Sample results
- Selected QC information such as surrogate recovery
- Associated blank results
- Completed chain-of-custody (COC) form and sample receipt information

Level 3 – Laboratory Analyses

The purposes of Level 3 data include the following:

- To further define the nature and extent of soil and groundwater contamination at Site 88
- To define the risk associated with soil and groundwater contamination
- To define the fate and transport mechanisms of site-related contaminants

The list of methods and the corresponding target compound lists have been designed to fully evaluate the potential for contamination from past site activities. EPA-approved methods from the current edition of *SW-846, Test Methods for Evaluating Solid Waste,* will be used to analyzed samples. Data package deliverables are summarized in **Table A-4-2.**

TABLE B.4-2
Level 3 Data Package Deliverables (Standard Deliverable Package)
Quality Assurance Project Plan, Site 88, MCB Camp Lejeune

All Analytical Fractions
Case Narrative
Sample ID Cross Reference Sheet (Lab IDs and Client IDs)
Completed chain of custody (COC) form and any sample receipt information
Any analytical/procedural changes (copies of "Confirmation of Communication")
Copies of non-conformance memos and corrective actions
GC/MS Organic Analyses
Form 1 – Sample Results
Form 2 – Surrogate Recovery Summary
Form 3 – MS/MSD Accuracy and Precision Summary
Form 4 – Method Blank Summary
Form 5 – Instrument Tuning Summary
Form 6 – Initial Calibration Summary
Form 7 – Continuing Calibration Summary
Form 8 – Internal Standard Summary
Metals
Form 1 – Sample Results
Form 2A – Initial and Continuing Calibration Summary
Form 3 – Initial and Continuing Calibration Blanks and Method Blanks Summary
Form 4 – Interference Check Standard Summary
Form 5A - Pre-digestion Matrix Spike Recoveries Summary
Form 6 – Native Duplicate or MS/MSD Precision Summary
Form 7 – Laboratory Control Sample Recovery Summary
Form 8 – Method of Standard Addition (if necessary)
Form 9 – Serial Dilution
Form 10 – Instrument or Method Detection Limit Summary
Form 12 – Linear Range Summary
Form 13 – Preparation Log Summary
Form 14 – Analytical Run Sequence and GFAA Post-spike Recovery Summary
General Chemistry
Includes potentiometric, gravimetric, colorimetric, and titrimetric analytical techniques. Examples, TRPH (418.1), TOC, etc. The following forms must be included (where applicable)
Form 1 – Sample Results
Form 2A – Initial and Continuing Calibration Summary
Form 3 – Initial and Continuing Calibration Blanks and Method Blanks Summary
Form 5A – Matrix Spike and Duplicate (MS/MSD) Recoveries Summary
Form 6 – Native Duplicate and MS/MSD Precision Summary
Form 7 – Laboratory Control Sample Recovery Summary

TABLE B.4-2
Level 3 Data Package Deliverables (Standard Deliverable Package)
Quality Assurance Project Plan, Site 88, MCB Camp Lejeune

Form 10 – Instrument or Method Detection Limit Summary
Form 13 – Preparation Log Summary

B.4.3 QA Objectives for Chemical Data Management

Analytical performance requirements are expressed in terms of precision, accuracy, representativeness, comparability, and completeness (PARCC). Brief definitions for each PARCC parameter are presented below.

Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Precision is estimated from analytical data and cannot be measured directly. The precision of a duplicate determination can be expressed as the relative percent difference (RPD).

Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Accuracy is estimated through the use of known reference materials or matrix spikes. It is calculated from analytical data and is not measured directly. Spiking of reference materials into a sample matrix is the preferred technique because it provides a measure of the matrix effects on analytical accuracy. Accuracy is defined as percent recovery (P).

Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition. Representativeness will be assessed by reviewing the presence/absence of contaminants in method blanks, trip blanks, and equipment blanks; sample condition/integrity upon receipt and storage at the laboratory; and laboratory adherence to sample holding times. In addition, the effects of sample matrix interferences, if any, will be evaluated to determine possible data impact.

Comparability

Comparability is another qualitative measure designed to express the confidence with which one data set may be compared to another. Sample collection and handling techniques, sample matrix type, and analytical method all affect comparability. Comparability is limited by the other PARCC parameters because data sets can be compared with confidence only when precision and accuracy are known.

Completeness

Completeness is defined as the percentage of valid measurements compared to the total number of measurements made for a specific sample matrix and analysis. The completeness goal for analytical data is 90 percent. All validated data will be used. During the data validation process, an assessment will be made of whether the valid data are sufficient to meet project objectives. If sufficient valid data are not obtained, corrective action (CA) will be initiated by the PM.

B.5 Sampling Procedures

Sampling locations and procedures are discussed in Section 4 of the Work Plan and Sections 4 and 6 of the *Field Sampling Plan* (Appendix A).

B.6 Sample Custody

A sample is physical evidence collected from a waste site, the immediate environment, or another source. Because of the potential evidentiary nature of samples, the possession of samples must be traceable from the time the samples are collected until they are introduced as evidence in enforcement proceedings.

COC procedures are used to maintain and document sample possession for enforcement purposes. The principal documents used to identify samples and to document possession are:

- Packing Lists
- COC Records
- Air Bills (such as Federal Express, UPS)
- Field Logbooks
- Color photographs of the field activities

Sample custody and COC records will be maintained by the field team until delivered to the laboratory. Sample shipping information from each day will be maintained by the FTL and relayed to the laboratory as soon as possible after sample pickup. These documents may be introduced as evidence should a site investigation result in legal action. To document sample possession, COC procedures are followed.

B.6.1 Definition of Custody

A sample is under the field team's custody if one or more of the following criteria are met:

- It is in the field team's possession.
- It is in the field team's view, after being in the field team's possession.
- It was in the field team's possession and then the field team locked it up to prevent tampering.
- It is in a designated secure area.

B.6.2 Field Custody

In collecting samples, the amount collected should be only enough to provide a good representation of the media being sampled. To the extent possible, the quantity and types of samples and sample locations are determined before the actual field work begins.

The following procedures will be used to document, establish, and maintain custody of field samples:

- Labels will be completed for each sample with waterproof ink, making sure that the labels are legible and affixed firmly on the sample container.

- All sample-related information will be recorded in the site logbook.
- The field sampler will retain custody of the samples until they are transferred or properly dispatched.
- To simplify the COC record and minimize potential problems, as few people as possible will handle the samples or physical evidence. One individual from the field sampling team will be designated as the responsible individual for all sample transfer activities. This field investigator will be responsible for the care and custody of the samples until they are properly transferred to another person or facility.
- All samples will be accompanied by a COC record, which documents the transfer of custody of samples from the field investigator to another person, the laboratory, or other organizational elements. Each change of possession must be accompanied by a signature for relinquishment and receipt of the samples.
- Completed COC forms will be placed in a plastic cover, which is then placed inside the shipping container used for sample transport from the field to the laboratory.
- When samples are relinquished to a shipping company for transport, the tracking number from the shipping bill or receipt will be recorded on the COC form or in the site logbook.
- Custody seals will be used on the shipping containers when samples are shipped to the laboratory to inhibit sample tampering during transportation.

B.6.3 Sample Labels

The sampling location identification and sample labeling, handling, and shipping must be performed using standardized and well-documented procedures, so that a sample can be tracked to its point of origination. Tracking will be performed from the time of sampling until the analytical data are released from the laboratory. The effectiveness of the tracking process will determine the integrity of the samples. Therefore, a sample numbering system with a tracking mechanism that allows the retrieval of sample information, including sampling locations, date, time, and analytical parameters must be used. Procedures for this system are provided in the project Work Plan. The method of sample identification to be used depends on the type of sample collected and the sample container type, as follows.

- Samples collected for in-situ field analysis are those collected for specific field analyses or measurements for which the data are recorded directly in the field logbooks or recorded on field data sheets, along with sample identity information, while in the custody of the sampling team. Examples are samples for measurement of field pH, specific conductance, and temperature.
- Samples other than those collected for in-situ field measurements or analyses are to be identified on a sample label affixed to the sample container by the FTL. The following information must be included on the label:
  - Laboratory
  - Project name (and number where appropriate)

- Sample ID
- Station ID
- Date (for key to sampling round)
- Preservation
- Analysis
- Sampler's initials, date, and military time

B.6.4 Chain-of-Custody Record

Samples are accompanied by a COC record, which will contain the information described in Section 6.5.

B.6.5 Transfer-of-Custody and Shipment

When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC record. This record documents custody transfer from the sampler to the analyst at the laboratory.

Samples will be packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate COC record accompanying each shipping container. Shipping containers will be sealed with custody seals for shipment to the laboratory. Courier name(s), and other pertinent information, will be entered in the '"Received By" section of the COC record.

When samples are split with a facility owner or agency, this information will be noted in the "Sample Remarks" section of the COC record and will be signed by both the sampler and the recipient. If the split is refused, the refusal will be noted and signed by both parties. The "Sample Remarks" section will also indicate if a representative is unavailable or refuses to sign. When appropriate, as in the case of the representative being unavailable, the COC record should contain a statement that the samples were delivered to the designated location at the designated time.

All shipments will be accompanied by the COC record identifying their contents. The original record and yellow copy will accompany the shipment to the laboratory, and the pink copy will be retained by the FTL.

If sent by mail, the package will be registered with return requested. If sent by common carrier, a bill of lading will be used. Freight bills, postal service receipts, and bills of lading will be retained as part of the permanent documentation.

B.6.6 Laboratory Chain-of-Custody Procedures

When samples are shipped to the laboratory, they will be placed in containers that are sealed on each side with at least one custody seal. A designated sample custodian will accept custody of the shipped samples following the procedure outlined below.

When sample analyses and necessary QA checks have been completed in the laboratory, the unused portion of the sample will be disposed of properly. All identifying stickers, data

sheets, and laboratory records will be retained as part of the documentation. Sample containers and remaining samples will be disposed in compliance with all federal, state, and local regulatory requirements.

Sample Receipt

A designated sample custodian will accept custody of the shipped samples and verify that the packing list sample numbers match those on the COC record. The custodian will enter pertinent information as to shipment, pickup, and courier in the "Sample Remarks" section of the COC record, and enter the sample numbers into a field logbook, which is arranged by project code and station number. Upon receipt of the samples, the custodian will check the original COC and request-for-analysis documents and compare them with the labeled contents of each sample container for corrections and traceability. The sample custodian will sign the COC and record the date and time received. The sample custodian also will assign a unique laboratory sample number to each sample. Cooler temperature (temperature vial) will be checked and recorded.

Care will be exercised to annotate any labeling or descriptive errors. If discrepancies occur in the documentation, the laboratory will immediately contact the FTL as part of the CA process. A qualitative assessment of each sample container will be performed to note anomalies, such as broken or leaking bottles. This assessment will be recorded as part of the incoming COC procedure.

Sample Storage

The laboratory custodian will use the sample identification number and assign a unique laboratory number to each sample, and is responsible for seeing that all samples are transferred to the proper analyst or stored in the appropriate secure area. The laboratory will send a sample acknowledgement letter to the PM or FTL as a record of the shipment's arrival and the condition of the containers. Any discrepancy will be identified by the laboratory custodian and CAs performed. The project chemist may need to provide guidance concerning additional actions. A copy of the sample acknowledgement letter will be retained with the COC by the PM.

Data Recording

The custodian will distribute samples to the appropriate analysts. Laboratory personnel are responsible for the care and custody of samples from the time they are received until the sample is exhausted or returned to the custodian. The data from sample analyses are recorded on the laboratory report form.

B.6.7 Documentation Procedures

Field documentation for activities at MCB Camp Lejeune will consist of one or more site-specific field logbooks, field forms, sample logs/labels, and an equipment calibration log. Each logbook will be identified uniquely by project task and consecutively numbered. For extended field activities, logbooks will be maintained onsite until complete, then stored in the project files.

Photographs will be taken during key field activities. The photographs will be collected at the end of the field work and will be submitted to the MCB Camp Lejeune project manager within 2 weeks of the completion of field work.

Sample Identification

An electronic sample tracking program will be used to manage the flow of information from the field sampling team to the laboratory and to internal and external data users. The tracking program is used to produce sample labels and COC forms and to manage the entry of sampling-related data, such as station locations and field measurements.

The method of sample identification used depends on the type of sample collected and the sample container.

- The field analysis data are recorded in field logbooks or on data sheets, along with sample identity information, while in the custody of the sampling team.
- Labels for samples sent to a laboratory for analysis will be produced electronically. If they cannot be produced electronically, they must be written in indelible ink. The following information typically is included on the sample label:
  - Site name or identifier
  - Sample identification number
  - Date and time of sample collection
  - Sample matrix or matrix identifier
  - Type of analyses to be conducted

Each analytical sample will be assigned a unique number of the following format:

Site # - Media/Station # or QA/QC – Depth/Round

where

Site #	IR88, indicating Site 88 under the Installation Restoration Program
Media	MW = Monitoring well boring
	GW = Groundwater
	IS = In-situ sampled boring
Station #	Unique identification number for each soil boring or monitoring well
QA/QC	FB = Field blank
	D = Duplicate sample (following sample type/number)
	TB = Trip blank
	ER = Equipment blank
	MS/MSD = Matrix spike/matrix spike duplicate

Depth/Round	Depth indicators will be used for soil samples. The number will reference the depth interval of the sample. For example, 01 = 6 to 8 feet below ground surface (bgs), 02 = 8 to 10 feet bgs, 03 = 10 to 12 feet bgs, etc.

Using this format, the sample designation IR88-IS64-04D refers to a duplicate sample, collected at a depth of 12 to 14 feet bgs, from in-situ sampled soil boring #64 at Site 88. The sample designation IR88-ERSB01-02 refers to the first equipment blank sample collected from soil sampling equipment at Site 88 in 2002.

This sample designation format will be followed throughout the remedial investigation at Site 88. Required deviations to this format will be documented in the field logbook.

Field Logs

Field logs will consist of all associated field logbooks and field forms.

Site Logbook

The site logbook chronicles field investigation activities, but does not have the same level of detail as the field logbook. The site logbook delineates conditions and activities that occur on a given day and references the appropriate field logbooks and forms for specific information. The site logbook also is used to record field changes, along with supporting rationale (Attachment 1).

The responsible person for the field effort will complete the site logbook. Pages will not be removed from the document. Partially used pages will be lined out, dated, and initialed to prevent data entry at a later date.

The front cover or first page of the site logbook must list the project name, the project number, and dates of use. The following items are to be included, as appropriate to the work scope, in the site logbook:

- Date
- Weather conditions
- List of CH2M HILL personnel, subcontractor personnel, and site visitors by name, title, organization, and purpose, who entered the project area during the day
- Brief descriptions of activities conducted
- Field changes or variances with references to the appropriate documentation of these changes
- Specific comments related to peculiar problems that occurred during the day, if any, and their resolution

Field Logbook

Information required on the cover of the site logbook also must be provided on the cover of each field logbook. Entries in the field logbook must be continuous through the day. Field

logbook pages, as well as the logbooks themselves, are numbered consecutively. The following information should be included in the field logbook:

- Date, time of specific activities, and physical location
- Weather conditions
- Names, titles, and organization of personnel onsite, names and titles of visitors, and times of visits
- Field observations, including specific details on sampling activities (including type of sampling, time of sampling, and sample numbers), a description of any field tests and their results, and references to any field forms used and type of document generated
- A detailed description of samples collected and any splits, duplicates, matrix spikes, or blanks that were prepared. A list of sample identification numbers, packaging numbers, and COC record numbers pertinent to each sample or referenced to the appropriate documentation should be noted.
- Specific problems, including equipment malfunctions and their resolutions
- A list of times, equipment types, and decontamination procedures followed (if different from those in the project Work Plan) or a reference to the appropriate documentation
- Photograph records

Additional information may be recorded at the discretion of the logbook user. Information to be recorded may include the following:

- Identification of well
- Static water level, depth, and measurement technique
- Presence of immiscible layers and detection methods
- Collection method for immiscible layers and sample identification numbers
- Total depth of well
- Well yield
- Purge volume and pumping rate
- Well purging times and volumes
- Sample withdrawal procedure
- Date and time of collection
- Well sampling sequence
- Types of sample containers and sample identification numbers
- Preservatives used
- Laboratory analyses requested
- Field analysis data and methods
- Sample distribution and transporter

Corrections to Documentation

All original handwritten data recorded in field logbooks, sample identification tags, COC records, and receipts-for-sample forms will be written with black, waterproof ink. Corrections must be marked with a single line, dated, and initialed. Documents such as site,

field, and calibration logbooks are not to be destroyed or discarded, even if illegible or inaccurate. None of these accountable control documents are to be destroyed or discarded, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on an accountable document assigned to one team member, the FTL may make corrections simply by drawing a single line through the error and entering the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All subsequent corrections must be initialed and dated.

Final Evidence File Documentation

Documentation, including voided entries, must be maintained within project files.

B.7 Calibration Procedures

Field and laboratory equipment must operate satisfactorily within specified operating limits before it can be expected to produce reliable and usable data for a project. Documentation concerning the calibration laboratory equipment should include instrument type, calibration frequency, reference standards used, calibration acceptance criteria, and calibration documentation procedures. Calibration applies to field and laboratory instruments, including balances, refrigerators, and ovens.

Instrument testing is primarily achieved by following the manufacturer's instructions with regard to proper voltages, carrier gas flow rates, temperatures, mass or retention time windows, and certified calibration standards. Practically all instruments come with manufacturer's instructions for initial setup, routine checks, CAs, and preventive maintenance.

B.7.1 Field Instruments

Field instruments will be calibrated at the beginning of each day using the method described by the manufacturer's instructions and then checked periodically during the day and at the end of the measurement period. Standards used to calibrate the field survey instruments will be traceable to National Institute of Standards and Testing (NIST) standards. All instrument calibration activities are documented in the field logbooks.

The water quality indicators will be decontaminated before each sample is measured. The probes will be rinsed three times with ASTM Type II water before storage each day. The meters will be checked for battery charge and physical damage each day. The meters and standard solutions will be stored in a cool, dry environment. Standard solutions will be discarded before they expire.

All field instruments will be set up and operated in strict accordance with the manufacturer's instructions. When the operation of these instruments needs modification because of specific site or sample conditions, such modification will be documented in the instrument logs and field logbooks.

B.7.2 Laboratory Equipment

Laboratory instruments will be calibrated in accordance with the manufacturer's directions and applicable method specifications. Laboratory instrument calibration procedures will be summarized in the laboratory QAP, which will be reviewed and approved by the PC or designee before samples are submitted for analysis.

B.8 Analytical Procedures

B.8.1 Field Testing and Screening

All field parameters will be analyzed in accordance with standard operating procedures (SOPs) for the individual equipment. Field parameters include total organic vapors, pH, specific conductance, temperature, and turbidity.

B.8.2 Laboratory Methods

The parameters to be analyzed and the specific analytical methods to be used are listed in **Table 4-1** in Work Plan.

B.9 Data Reduction, Validation, and Reporting

The data quality evaluation process is used to assess the effect of the overall analytical process on the usability of the data.

B.9.1 Level 1 – Field Survey Data

Field instruments used to collect field survey data (or bulk measurements, such as pH or conductivity) are direct readings, thus making field calculations and subsequent data reduction unnecessary. Field data will be recorded in the site logbooks by appropriately trained field personnel. Field data will include the following:

- Instrument identification
- Calibration information (standards used and results)
- Date and time of calibration and sample measurement
- Sample results
- Supporting information if appropriate

Data will be reviewed by the FTL, who is responsible for the collection and verification of all field data while in the field. Data initially will be accepted or rejected by the FTL before leaving the sampling site. Extreme readings (readings that appear significantly different from other readings at the same site) will be accepted only after the instrument has been checked for malfunction and the readings verified by re-testing.

Field documentation, sample data, instrument calibrations, and QC data will be reviewed by the PM (or a designee) before being included in the project files.

B.9.2 Level 2 – Screening Analyses

Level 2 data includes the samples submitted to the laboratories for physical parameter testing and IDW characterization. Samples submitted for Level 2 analysis will require the delivery of a limited data package, which includes:

- Case narrative
- Sample results
- Selected QC information, such as surrogate recovery
- Associated blank results
- Completed COC forms and sample receipt information

The PC will review the supporting information and will provide a summary report to the PM at the end of the field effort.

B.9.3 Laboratory Analyses

The PC or designee will perform data quality evaluation. The data quality evaluation process is used to assess the effect of the overall analytical process on the usability of the data. The two major categories of data evaluation are laboratory performance and matrix interferences. Evaluation of laboratory performance is a check for compliance with the method requirements and identifies whether the laboratory did, or did not, analyze the samples within the limits of the analytical method. Evaluation of the matrix interferences is more subtle and involves analysis of several results including surrogate spike recoveries, matrix spike recoveries, and duplicate sample results.

Before the analytical results are released by the laboratory, both the sample and QC data will be reviewed carefully to verify sample identify, instrument calibration, detection limits, dilution factors, numerical computations, accuracy of transcriptions, and chemical interpretations. Additionally, the QC data will be reduced and spike recoveries will be included in control charts, and the resulting data will be reviewed to ascertain whether they are within the laboratory-defined limits for accuracy and precision. Any non-conforming data will be discussed in the data package cover letter and case narrative. The laboratory will retain all of the analytical and QC documentation associated with each data package.

The data package will be reviewed by the PC using the process outlined in the following guidance documents:

- Control Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA, 1994)
- Contract Laboratory Program National Function Guidelines for Organic Data Review (EPA, 1994)

For non-CLP methods, the validation will be performed in a process analogous to the National Function Guidelines, but will use QC criteria established by the method.

The data review and validation process is independent of the laboratory's checks; it focuses on the usability of the data to support the project data interpretation and decision-making process. Areas of review include data package completeness, holding time compliance, initial and continuing calibration, spiked sample results, method blank results, and duplicate sample results. A data review worksheet will be completed for each data package. Acceptance criteria for each area of review are specified in the analytical method.

Sample results that do not meet the acceptance limit criteria will be indicated with a qualifying flag, which is a one- or two-letter abbreviation that indicates a possible problem with the data. Flags used in the text may include the following:

- U – Undetected. Samples were analyzed for this analyte, but it was not detected above the method detection limit (MDL) or instrument detection limit (IDL).
- UJ – Detection limit estimated. Samples were analyzed for this analyte, but the results were qualified as not detected. The results are estimated.
- J – Estimated. The analyte was present, but the reported value may not be accurate or precise.

- R – Rejected. The data are unusable. (Note: Analyte/compound may or may not be present.)

It is important to note that laboratory qualifying flags are included on the data summary forms that are submitted by the laboratory. However, during the data review and validation process, the laboratory qualifying flags are evaluated and replaced with the project-specific validation flags.

Once each of the data packages has been reviewed, and the data review worksheets completed, then the entire data set will be evaluated for overall trends in data quality and usability. Information summarized as part of the data quality evaluation may include chemical compound frequencies of detection, dilution factors that might affect data usability, and patterns of target compound distribution. The data set will also be evaluated to identify potential data limitations or uncertainties in the laboratory. Additional areas of review are listed below.

Field and Laboratory Blank Contamination

The appearance and concentration of target compounds in field and laboratory blanks as well as environmental samples will be reviewed. Common field sampling and laboratory contaminants detected in blanks include acetone, methylene chloride, and phthalates. Acetone and methylene chloride are used to extract samples in the laboratory, and hence, are common laboratory contaminants. Phthalates (such as bis(2-ethylhexyl)phthalate) are used as plasticizers and are often introduced during sample handling.

If these compounds are encountered in a method blank at a concentration greater than the practical quantitation limit (PQL), CAs will be taken in an attempt to eliminate these compounds. These compounds may also be detected in field blanks above the PQL. In either case, all analytical data above the PQL associated with these compounds will be flagged to indicate possible cross-contamination.

Surrogate Spike Recoveries

Surrogate spike compounds are added to each sample for the organic analytical methods. Surrogate spike compounds are structurally similar (but not identical) to target compounds and should behave in a similar manner during analysis. Surrogate spike recoveries are used to monitor both laboratory performance and matrix interferences. Surrogate spike recoveries from field and laboratory blanks are used to evaluate laboratory performance because these blanks represent an ideal sample matrix. Surrogate spike recoveries for field samples are used to evaluate the potential for matrix interferences.

When surrogate spike recoveries for field samples fall outside the method target acceptance windows, the samples are re-extracted if appropriate, then re-analyzed. If the surrogate spike recovery is still outside the acceptance window for the re-analyzed sample, then the sample results are qualified as affected by matrix interferences.

Matrix Spike Recoveries

For this QC measure, three aliquots of a single sample are analyzed – one normal and two spiked with the same concentration of matrix spike compounds. Unlike the surrogate spike

compounds, matrix spike compounds are found on the method target compound list. Spike recovery is used to evaluate potential matrix interferences, as well as accuracy. The duplicate spike results are compared to evaluate precision.

Laboratory Control Samples

An aliquot of ASTM Type II water or "Ottawa sand" for organic analyses is spiked with target analytes or compounds at concentrations in the middle of the linear calibration range, and then prepared and analyzed with a batch of samples. The laboratory control sample is used to ensure quality control for each preparation batch.

Duplicate Sample Results

Duplicate samples will be collected and submitted for laboratory analysis. Both the native and duplicate samples will be analyzed for the same parameters. Target compounds that are detected in both the native and duplicate samples will be compared and the precision estimated for the sample results calculated.

Laboratory Data Reporting

Laboratory data will be reported in Level 3 QC and validated for risk assessment. Level 3 reporting includes all QC and calibration summaries for a project-specific batch of samples as listed in **Table 4-2** in Work Plan. Matrix-specific QC is performed relative to project sample delivery groups (SDGs).

B.10 Internal Quality Control

B.10.1 Field Measures

Field sampling QC procedures will include collecting trip blanks, field blanks, equipment blanks, field duplicates, and MS/MSD samples, as discussed in Appendix A. These QC samples will be submitted blind to the laboratory. Field measurement QC procedures will include the calibration requirements discussed in Section 7 of this QAPP.

Samples will be collected by personnel wearing Level D personal protection equipment (PPE).

B.10.2 Routine Analytical Services

Laboratory QC procedures will include the following:

- Analytical methodology according to the specific methods listed in **Table 4-1** in Work Plan.
- Instrument calibrations and standards as defined in the specific methods listed **in Table 4-1**
- Laboratory blank measurements at a minimum frequency of 5 percent or 1-per-batch
- Accuracy and precision measurements at a minimum frequency of 5 percent or 1-per-set
- Data reduction and reporting according to the specific methods listed in **Table 4-2** and the specifications outlined in Section 9 of this QAPP
- Laboratory documentation according to the specifications outlined in Section 9 of this QAPP

B.11 Performance and System Audits

Performance and systems will be audited to verify documentation and implementation of the project-specific QAPP, to identify nonconformance, and to verify correction of identified deficiencies.

Assessment activities may include surveillance, inspections, peer review, management system review, readiness review, technical systems audit, performance evaluation, and data quality assessment. The Quality Assurance Control Manager (QACM) will be responsible for initiating audits, selecting the audit team, and overseeing audit implementation.

The QACM, or designee, in consultation with the PM, will evaluate the need for an independent audit. The client may also perform independent project audits. Performance audits are used to quantitatively assess the accuracy of analytical data through the use of performance evaluation and blind check samples. Laboratory performance will be audited by the QACM or designee.

B.11.1 Project Systems Audit

A systems surveillance of operations may be required by the project-specific Work Plan and would be used to review the total data generation process. This will include onsite review of the field operational system, physical facilities for sampling, and equipment calibrations. Informal document control surveillance will consist of checking each document for completeness, including such items as signatures, dates, and project numbers.

An audit report summarizing the results and corrections will be prepared and entered in the project files.

B.11.2 Technical Performance Audits

The FTL or a designated representative will conduct an informal surveillance of the field activities. Surveillance for completeness will include the following items:

- Sample labels
- COC records
- Field logbooks
- Sampling operations

The first three items above will be checked for completeness. Sampling operations will be reviewed to determine if they are being performed as stated in the project-specific Work Plan or as directed by the FTL. A performance surveillance may be conducted by the PM and the FTL during the first week of sampling if it is deemed necessary by the PM, FTL, or client. The surveillance may focus on verifying that proper procedures are followed so that subsequent sample data will be valid. Before the surveillance, a checklist will be prepared

by the PM and the FTL to serve as a guide for the performance surveillance. The surveillance may verify the following:

- Collection of samples follows the available written procedures
- COC procedures are followed for traceability of sample origin
- Appropriate QC checks are being made in the field and documented in the field logbook
- Specified equipment is available, calibrated, and in proper working order
- Sampling crews are adequately trained
- Record-keeping procedures are being followed and appropriate documentation is maintained
- CA procedures are followed

An audit report summarizing the results and corrections will be prepared and entered in the project files.

B.11.3 Field Audits

Field audits are not currently anticipated during the remedial investigation at Site 88, but will be performed if necessary.

B.11.4 Laboratory Audits

The analytical laboratory will conduct both internal and external QC checks. External QC checks include participation in EPA's certification and performance evaluation programs. The results of quarterly performance evaluation samples will be made available to the PM upon request. Internal QC checks (duplicates, blanks, and spiked samples) will be performed in accordance with the approved methods.

Laboratory systems are audited annually and as required by specific projects. The laboratories are required to submit a laboratory QAP and relevant SOPs before the field effort begins. During data evaluation and data use, if any problems are noted, specific CAs will be implemented on a case-by-case basis. An additional systems audit may be requested if warranted.

The laboratory will be required to perform the following:

- Monthly project review of 10 percent of all projects done by the QA department
- Audits by the laboratory QA manager at a frequency greater than specified in the laboratory QAP
- Special audits by the QACM or corporate management when a problem is suspected
- Yearly audits by the corporate QACM

B.12 Preventive Maintenance

B.12.1 Field Equipment

The field personnel operating the field equipment and appropriate offsite laboratory chemists are responsible for the maintenance of their respective instruments. Preventive maintenance will be provided on a scheduled basis to minimize down time and the potential interruption of analytical work. All instruments will be maintained in accordance with the manufacturer's recommendations and normal approved laboratory practice.

Scheduled periodic calibration of testing equipment does not relieve field personnel of the responsibility of using properly functioning equipment. If a project team member suspects an equipment malfunction, the device will be removed from service, tagged so that it is not inadvertently used, and the appropriate personnel notified so that a recalibration can be performed or a substitute piece of equipment can be obtained.

B.12.2 Laboratory Equipment

Designated laboratory personnel will be trained in routine maintenance procedures for all major instrumentation. When repairs become necessary, they will be made by either trained staff or trained service engineers/technicians employed by the instrument manufacturer. The laboratory will have multiple instruments that will serve as backup to minimize the potential for downtime.

Preventive maintenance will be performed according to the procedures delineated in the manufacturer's instrument manuals, including lubrication, source cleaning, detector cleaning, and the frequency of such maintenance. Procedures should be listed in greater detail in the laboratory's QAP.

Chromatographic carrier gas purification traps, injector liners, and injector septa will be cleaned or replaced on a regular basis. Precision and accuracy data will be examined for trends and excursions beyond control limits to identify evidence of instrument malfunction. Maintenance will be performed when an instrument begins to degrade, as evidenced by the degradation of peak resolution, shift in calibration curves, decrease in sensitivity, or failure to meet one or more of the QC criteria.

Instrument downtime will be minimized by keeping adequate supplies of all expendable items (i.e., an expected lifetime of less than 1 year). Selected items include gas tanks, gasoline filters, syringes, septa, GC columns and packing, ferrules, printer paper and ribbons, pump oil, jet separators, open-split interfaces, and mass spectroscopy (MS) filaments.

B.12.3 Instrument Maintenance Logbooks

All maintenance will be documented in permanent logs that will be available for review by auditing personnel. Both scheduled and unscheduled maintenance required by operational failures will be recorded. The designated laboratory operations coordinator will review maintenance records regularly to ensure that required maintenance is occurring.

Instrument maintenance logbooks are maintained in laboratories at all times. The logbooks, in general, contain a schedule of maintenance, as well as a complete history of past routine and nonroutine maintenance. Laboratories will be audited by the project chemist prior to the start of analyses.

B.13 Specific Procedures Used to Assess Data

The final activity of the data quality evaluation is an assessment of whether the data meet the DQOs. The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected and that the resulting analytical data can be used to support the project decision making process.

Data assessment will follow the data review and validation described in Section 9 of this QAPP. An assessment report will be prepared at the end of the project. The report will summarize the findings of the data review/validation as relevant to project usage. Data accuracy, precision, and completeness values will be summarized in the assessment report. The following sections describe the quantitative definition of accuracy, precision, and completeness.

B.13.1 Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Precision is estimated from analytical data and cannot be measured directly. The precision of a duplicate determination can be expressed as the RPD and is calculated as follows:

$$RPD = \{(|X_1 - X_2|)/(X_1 + X_2)/2\} \times 100 = \left\{\frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}}\right\} \times 100$$

X_1 = native sample
X_2 = duplicate sample

B.13.2 Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Accuracy is estimated through the use of known reference materials or matrix spikes. It is calculated from analytical data and is not measured directly. Spiking of reference materials into a sample matrix is the preferred technique because it provides a measure of the matrix effects on analytical accuracy. Accuracy, defined as percent recovery (P), is calculated as follows:

$$P = \left[\frac{(SSR - SR)}{SA}\right] \times 100$$

[1] SSR=spiked sample result, SR=sample result (native), and SA=the spike concentration added to the spiked sample

B.13.3 Completeness

Completeness is defined as the percentage of measurements judged to be valid compared to the total number of measurements made for a specific sample matrix and analysis. Completeness is calculated using the following formula:

$$\text{Completeness} = \frac{\text{Valid Measurements}}{\text{Total Measurements}} \times 100$$

Experience on similar projects has shown that laboratories typically achieve about 90 percent completeness. All validated data will be used. During the data validation process, an assessment will be made of whether the valid data are sufficient to meet project objectives. If sufficient valid data are not obtained, CA will be initiated by the PM.

B.14 Corrective Actions

B.14.1 Field Activities

The PM is responsible for initiating CAs, which include problem identification, investigation responsibility assignment, investigation, action to eliminate the problem, increased monitoring of the effectiveness of the CA, and verification that the problem has been eliminated.

Documentation of the problem is important to the overall management of the study. A CA request form for problems associated with sample collection is completed by the person discovering the QA problem (Attachment 2). This form identifies the problem, establishes possible causes, and designates the person responsible for action. The responsible person will be either the PM or the FTL.

The CA request form includes a description of the CA planned and has space for follow-up. The PM verifies that the initial action has been taken and appears to be effective, and at an appropriate later date, checks to see if the problem has been resolved fully. The PM receives a copy of all CA request forms and enters them into the CA log. This permanent record aids the PM in follow-up and assists in resolving the QA problems.

Examples of CA include, but are not limited to, correcting COC forms, analysis re-runs (if holding time criteria permit), re-calibration with fresh standards, replacement of sources of blank contamination, or additional training in sampling and analysis. Additional approaches may include the following:

- Re-sampling and re-analyzing
- Evaluating and amending sampling and analytical procedures
- Accepting the data and acknowledging the level of uncertainty or inaccuracy by flagging the validated data and providing an explanation for the qualification

B.14.2 Laboratory Activities

The laboratory department supervisors review the data generated to verify that all QC samples have been run as specified in the protocol. Laboratory personnel will be alerted that CAs may be necessary if the following should occur:

- QC data are outside the warning or acceptable windows for precision and accuracy established for laboratory samples.
- Blanks contain contaminants at concentrations above the levels specified in the laboratory QAP for any target compound.
- Undesirable trends are detected in matrix spike recoveries or RPD between matrix spike duplicates.

- There are unusual changes in detection limits.
- Deficiencies are detected by the laboratory QA Director during internal or external audits, or from the results of performance evaluation samples.

If nonconformances including, but not limited to, analytical methodologies or QC sample results are identified by the bench analyst, CAs will be implemented immediately. CA procedures will be handled initially at the bench level by the analyst, who will review the preparation or extraction procedure for possible errors and check the instrument calibration, spike and calibration mixes, instrument sensitivity, etc. The analyst will immediately notify his/her supervisor of the problem and the investigation being made. If the problem persists or cannot be identified, the matter will be referred to the laboratory supervisor and QA/QC Officer for further investigation. Once resolved, full documentation of the CA procedure will be filed with the laboratory supervisor, and the QA/QC Officer will be provided a CA memorandum for inclusion in the project file if data are affected. CAs may include, but are not limited to, the following:

- Re-analyzing suspect samples
- Re-sampling and analyzing new samples
- Evaluating and amending sampling and/or analytical procedures
- Accepting data with an acknowledged level of uncertainty
- Recalibrating analytical instruments
- Qualifying or rejecting the data

Following the implementation of the required CA measures, data that are deemed unacceptable may not be accepted by the PM, and follow-up CAs may be explored. Details of laboratory CAs are provided in the laboratory QAP. CA requests will be documented with the form in Attachment 2.

B.15 Quality Assurance Project Plans

The purpose of QA reports is to document implementation of the QAPP. These reports include periodic assessments of measurement data accuracy, precision, and completeness of the results of performance audits, the results of system audits, and the identification of significant QA problems and recommended solutions.

The analytical laboratory will be responsible for submitting monthly progress reports to the PM. The PM is responsible for submitting these reports to the client, as required.

The final QA report will be attached as an appendix to the project report and may include the following:

- Data quality assessment in terms of PARCC, and the method detection limits
- The degree to which DQOs were met
- Limitations of the measurement data and usability of the data
- Applicability of the data to site conditions
- Laboratory QC activities, including a summary of planned versus actual laboratory QC activities, explanations for deviations, and an evaluation of data quality for each analysis for each medium
- Field QC activities, including a summary of planned versus actual field QC activities, explanations for deviations, and evaluations of the data quality of field QC samples/activities and estimated effect on sample data
- Data presentation and evaluation, including an assessment of sampling and analysis techniques, data quality for each analysis and each medium, and data usability

A final report will be submitted to the client after comments from the client and regulatory agencies have been incorporated.

FINAL

Attachment 1

Field Change Documentation

Field Change Documentation

Date: _____
Page _____ **of** _____

Project:

Project No.:

Applicable Document:

Change Description:

Reason for change:

Recommended disposition:

Impact on present and completed work:

Final disposition (MCB Camp Lejeune only)

Request by:
CH2M HILL Project Manager: _____ Date:_____
Approvals:
MCB Camp Lejeune Project Manager: _____ Date:_____

Attachment 2

Corrective Action Request Form

Corrective Action Request Form

Originator: _____ Date: _____

Person responsible for replying: _____

Description of problem and when identified: _____

_____

Sequence of Corrective Action (CA): (Note, if no responsible person is identified, submit this form directly to the PM)

State date, person, and action planned:

_____

_____

_____

_____

_____

CA initially approved by: _____ Date: _____

Follow-up date: _____

Final CA approval by: _____ Date: _____

Information copies to:

Responsible person:_____

Field Team Leader:_____

Project Manager: _____

Appendix C

FINAL

Site 88 Health & Safety Plan

Operable Unit No. 15 (Site 88)

Marine Corps Base

Camp Lejeune, North Carolina

Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

Contract No. N62470-95-D-6007

CTO-0250

LANTDIV Clean II Program

July 2003

Prepared by

CH2MHILL

CH2M HILL HEALTH AND SAFETY PLAN

This Health and Safety Plan (HSP) will be kept on the site during field activities and will be reviewed as necessary. The plan will be amended or revised as project activities or conditions change or when supplemental information becomes available. The plan adopts, by reference, the Standards of Practice (SOPs) in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual,* as appropriate. In addition, this plan adopts procedures in the project Work Plan. The Site Safety Coordinator (SSC) is to be familiar with these SOPs and the contents of this plan. CH2M HILL's personnel and subcontractors must sign Attachment 1.

Project Information and Description

PROJECT NO: 174056

CLIENT: LANTDIV

PROJECT/SITE NAME: Operable Unit 15, Site 88

SITE ADDRESS: MCB Camp Lejeune, North Carolina

CH2M HILL PROJECT MANAGER: Chris Bozzini/CLT

CH2M HILL OFFICE: Charlotte, North Carolina

DATE HEALTH AND SAFETY PLAN PREPARED: 1/7/2003

DATE(S) OF SITE WORK: Summer 2003

SITE ACCESS: Access to the site is restricted. The site is fenced in and is located on a military base. The site is located off the Main Service Road on Post Lane.

SITE SIZE: ~5 acres

SITE TOPOGRAPHY: Relatively level, gentle slope to Edwards Creek

PREVAILING WEATHER: High 70s-80s, Lows 40s-50s, humid (SE coastal plain)

SITE DESCRIPTION AND HISTORY:

MCB Camp Lejeune is located in Onslow County, North Carolina and covers approximately 236 square miles and includes 14 miles of coastline. The Base is bounded to the southeast by the Atlantic Ocean and to the northeast by State Route 24. The town of Jacksonville, North Carolina is located north of the Base.

Site 88 is located at the Base dry cleaners (Building 25) within a densely populated area of MCB Camp Lejeune. Barracks, office buildings, and other occupied structures are located adjacent to

Building 25. The USTs were installed in the 1940s and were used to store varsol, an early dry cleaning chemical. Tetrachloroethene replaced varsol in the 1970s and was stored in an AST. In the mid-1980s, the AST was taken out of service. The USTs were removed between November 1995 and January 1996.

A Focused RI was completed in 1998 that identified the limits of soil and groundwater contamination at the site, and a Supplemental SI (SSI) was completed in 2002 that identified the present limits of groundwater contamination at the site. In general, contaminated soil appears to be concentrated beneath the building and the parking lot to the northwest near Building 25. Groundwater contamination extends to a depth 50 feet below ground surface and extends approximately 700 feet to the northwest. Isolated areas of free phase dense non-aqueous phase liquid (DNAPL) exist beneath Building 25 and areas immediately north of the building.

A partial free phase liquid recovery has been completed in addition to a pre-surfactant remediation characterization and delineation study to address the DNAPL situation at Site 88. These studies have established the nature and extent of residual phase of DNAPL. Surfactant enhanced aquifer remediation (SEAR) was conducted to remove the residual phase DNAPL and some free phase DNAPL. This pilot program was completed in August 1999. Post SEAR monitoring was completed in Fiscal Year 2001.

In Fiscal Year 2001, several other interim remedial actions were also initiated. The Air Force started operations of the Reductive Anaerobic Bioremediation In-Situ Treatment Technology (RABITT) pilot scale test within the dissolved portion of the plume near monitoring wells 88-MW05 and 88-MW051W. This pilot test was scheduled to be completed in Fiscal Year 2002. In addition, the RAC started aggressive fluid vapor recovery (AVFR) activities at Site 88 by pumping free phase product monthly from six existing extraction wells.

Site 88 was added to the monitoring program in April 1999. Semi-annual monitoring was discontinued in the fourth quarter of Fiscal Year 2001. Baseline sampling was performed in July 2002 and results were reported in the SSI report.

DESCRIPTION OF SPECIFIC TASKS TO BE PERFORMED:

The tasks to be performed for this field Investigation are:

- Base engineering drawings will be used to identify underground utility easements. Video surveys of the stormwater sewer line and wastewater sewer line will be conducted in order to identify areas of deterioration that may have allowed solvents to leak into the subsurface. The video surveys will be used in conjunction with existing soil and groundwater chemical and physical data to select appropriate sampling locations along the underground utility corridors. Soil and groundwater samples will be collected using direct push technology (DPT) to evaluate the potential for contaminant migration along the utility corridors.

- Near surface soil samples (zero- to 2-feet bgs) will be collected from the grassy area on the north side of Building 25 and analyzed to evaluate potential exposure pathways by direct contact with surface soil. Soil from zero to 6-feet bgs will be evaluated for construction worker exposure during potential future excavation. Sampling will be conducted using DPT.

- A total of 26 monitoring wells will be installed at locations surrounding Site 88. These monitoring wells will serve to characterize the site lithology, monitor groundwater quality, and evaluate groundwater elevations and flow directions. A total of seven monitoring wells

will be installed in the shallow aquifer to depths ranging from 15 to 25 feet below ground surface (ft. bgs). Eleven monitoring wells will be installed in the intermediate aquifer to depths of approximately 50 ft bgs. Eight monitoring wells will be installed in the deep aquifer zone to a depth of 85 to 100 ft bgs. Discrete soil samples will be collected from the soil borings at regular depth intervals to characterize lithology and screen for the presence of VOCs.

- Geotechnical testing for vertical permeability grain size distribution, and porosity will be conducted using undisturbed soil samples collected by thin-walled Shelby tube samplers from the eight deep well borings and three of the intermediate depth well borings. Shelby tube samples will be collected from the silty aquitard layer (~20-22' bgs), the fine sand aquifer (45-47' bgs), and the silty fine sand aquitard layer (~70-72' bgs) for each deep boring. Undisturbed samples will be taken from the silty aquitard layer and the fine sand aquifer for the three selected intermediate wells.

- Groundwater samples will be collected from all new and existing permanent monitoring wells adjacent to Site 88 for field and laboratory analysis.

- Natural gamma logging of existing and newly installed deep monitoring wells will be performed in order to confirm the characterization of the lithology at Site 88. The geophysical logs will be compared with boring log descriptions completed by Baker Environmental in the Focused RI (1998) and the new boring logs by CH2M HILL on the new wells to provide an evaluation of the consistency in logging between firms and individuals.

- Aquifer testing will be conducted in the intermediate and deep aquifers. Each test will comprise of a monitored 72-hour pumping test followed by a recovery test. Existing monitoring wells will be used to monitor drawdown during the tests.

Site Map

This page is reserved for a Site Map.

Note locations of Support, Decontamination, and Exclusion Zones; site telephone; first aid station; evacuation routes; and assembly areas.

Table of Contents – Health and Safety Plan

C.1 Tasks to be Performed Under this Plan

C.1.1 Description of Tasks

(Reference Field Project Start-up Form)

Refer to project documents (i.e., Work Plan) for detailed task information. A health and safety risk analysis (Section 1.2) has been performed for each task and is incorporated in this plan through task-specific hazard controls and requirements for monitoring and protection. Tasks other than those listed below require an approved amendment or revision to this plan before tasks begin. Refer to Section 8.2 for procedures related to "clean" tasks that do not involve hazardous waste operations and emergency response (Hazwoper).

C.1.1.1 Hazwoper-Regulated Tasks

- Drilling
- Geoprobe boring
- Groundwater monitoring
- Aquifer testing
- Surface soil sampling
- Subsurface soil sampling
- Surveying
- Investigation-derived waste (drum) sampling and disposal
- Observation of material loading for offsite disposal

C.1.1.2 Non-Hazwoper-Regulated Tasks

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. **Prior approval from the Health and Safety Manager (HSM) is required before these tasks are conducted on regulated hazardous waste sites.**

TASKS	CONTROLS
• Electrical installation	• Brief on hazards, limits of access, and emergency procedures
• Mechanical installations (equipment, pumps, etc.)	• Post contaminant areas as appropriate (refer to Section 8.2 for details)
	• Sample and monitor as appropriate (refer to Section 5.0)

C.1.2 Task Hazard Analysis

(Refer to Section 2 for hazard controls)

POTENTIAL HAZARDS	TASKS									
		Drilling, geoprobe, and well installation & abandonment	Groundwater monitoring, aquifer testing				Surveying	IDW drum disposal	Observation of loading material for offsite disposal	
Flying debris/objects		X						X	X	
Noise > 85dBA		X							X	
Electrical		X	X							
Suspended loads		X							X	
Buried utilities, drums, tanks		X								
Slip, trip, fall		X	X				X	X	X	
Back injury		X	X					X		
Confined space entry							X			
Trenches / excavations										
Visible lightning		X	X				X	X	X	
Vehicle traffic									X	
Elevated work areas/falls										
Fires		X						X		
Entanglement		X								
Drilling		X								
Heavy equipment		X							X	
Working near water										
Working from boat										
IDW Drum Sampling										

C.2 Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the SSC for clarification.

In addition to the controls specified in this section, Project-Activity Self-Assessment Checklists are contained in Attachment 6. These checklists are to be used to assess the adequacy of CH2M HILL and subcontractor site-specific safety requirements. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. Self-assessment checklists should be completed early in the project, when tasks or conditions change, or when otherwise specified by the HSM. The self-assessment checklists, including documented corrective actions, should be made part of the permanent project records, and be promptly submitted to the HSM.

Project-specific frequency for completing self-assessments: **Weekly or at the beginning of each new phase of work.**

C.2.1 Project-Specific Hazards

C.2.1.1 Vinyl Chloride

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met. The term "competent person" means a person who is capable of recognizing and evaluating employee exposure to hazardous substances or to other unsafe conditions and is capable of specifying the necessary protection and precautions to be taken to ensure the safety of employees as required by the particular regulation under the condition to which it applies.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Vinyl Chloride is considered a "Confirmed Human Carcinogen."
- An exposure limit of 1 ppm exists for this material.
- A Short Term Exposure Limit of 5 ppm (STEL: 15 minutes) exists for this material.
- Vinyl Chloride has a mild, sweet, chloroform-like odor.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.

C.2.1.2 1,1-Dichloroethane

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.

- An exposure limit of 100 ppm and an IDLH of 3,000 ppm exists for this material.
- Symptoms and effects of exposure include CNS depression, skin irritation; liver, kidney and lung damage.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.

C.2.1.3 1,1-Dichloroethene

- Do not enter regulated areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- 1,1-Dichloroethene is a suspected human carcinogen.
- An exposure limit of 1 ppm and an IDLH of 50 ppm exist for this material.
- Symptoms and effects of exposure include irritated eyes, kidney and liver damage, and CNS depression.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.

C.2.1.4 Trichloroethylene (TCE)

- Do not enter regulated areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- TCE is considered a "Potential occupational carcinogen".
- An exposure limit of 50 ppm and an IDLH of 1,000 ppm exist for this material.
- Symptoms and effects of exposure include headache, vertigo, visual disturbance, eye and skin irritation, fatigue, giddiness, tremors, sleepiness, nausea, vomiting, dermatitis, cardiac arrhythmia, paresthesia, liver injury.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained by the competent person.

C.2.1.5 Tetrachloroethylene (PCE)

- Do not enter regulated areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- PCE is considered a "Potential occupational carcinogen".
- An exposure limit of 25 ppm and an IDLH of 150 ppm exist for this material.

- Symptoms and effects of exposure include eye, nose, and throat irritation; nausea; flushed face and neck; vertigo; dizziness; sleepiness; skin redness; headache; liver damage.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained by the competent person.

C.2.1.6 cis-1,2-Dichloroethene

- cis-1,2-dichloroethene is flammable.
- cis-1,2-dichloroethene is harmful by inhalation, in contact with skin and if swallowed.
- cis-1,2-dichloroethene is irritating to eyes, respiratory system and skin.
- Target organs include CNS and liver.
- Keep away from ignition source, and wear appropriate protective clothing.

C.2.1.7 trans-1,2-dichloroethene

- trans-1,2-dichloroethene is flammable, keep away from ignition source.
- trans-1,2-dichloroethene is harmful by inhalation, in contact with skin and if swallowed.
- trans-1,2-dichloroethene is irritating to eyes, respiratory system, and skin.
- Target organs include CNS, liver and kidneys.
- Wear appropriate protective clothing.

C.2.1.8 Drilling

(Reference CH2M HILL SOP HS-35, *Drilling*)

- Only authorized personnel are permitted to operate drill rigs.
- Stay clear of areas surrounding drill rigs during every startup.
- Stay clear of the rotating augers and other rotating components of drill rigs.
- Stay as clear as possible of all hoisting operations. Loads shall not be hoisted overhead of personnel.
- Do not wear loose-fitting clothing or other items such as rings or watches that could get caught in moving parts. Long hair should have it restrained.
- If equipment becomes electrically energized, personnel shall be instructed not to touch any part of the equipment or attempt to touch any person who may be in contact with the electrical current. The utility company or appropriate party shall be contacted to have line de-energized prior to approaching the equipment.
- Smoking around drilling operations is prohibited.

C.2.1.9 IDW Drum Disposal

Personnel are permitted to handle and/or sample drums containing investigation-derived waste (IDW) only; handling or sampling other drums requires a plan revision or amendment approved by the CH2M HILL HSM. The following control measures will be taken when sampling drums containing IDW:

- Minimize transportation of drums.
- Sample only labeled drums or drums known to contain IDW.
- Use caution when sampling bulging or swollen drums. Relieve pressure slowly.
- If drums contain, or potentially contain, flammable materials, use non-sparking tools to open.
- Picks, chisels, and firearms may not be used to open drums.
- Reseal bung holes or plugs whenever possible.
- Avoid mixing incompatible drum contents.
- Sample drums without leaning over the drum opening.
- Transfer the content of drums using a method that minimizes contact with material.
- PPE and air monitoring requirements specified in Sections 4 and 5 must address IDW drum sampling.
- Spill-containment procedures specified in Section 7 must be appropriate for the material to be handled.

C.2.2 General Hazards

C.2.2.1 General Practices and Housekeeping

(Reference CH2M HILL SOP HS-20, *General Practices*)

- Site work should be performed during daylight hours whenever possible. Work conducted during hours of darkness require enough illumination intensity to read a newspaper without difficulty.
- Good housekeeping must be maintained at all times in all project work areas.
- Common paths of travel should be established and kept free from the accumulation of materials.
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions.
- Provide slip-resistant surfaces, ropes, and/or other devices to be used.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.

- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.

C.2.2.2 Hazard Communication

(Reference CH2M HILL SOP HS-05, *Hazard Communication)*

The SSC is to perform the following:

- Complete an inventory of chemicals brought on site by CH2M HILL using Attachment 2.
- Confirm that an inventory of chemicals brought on site by CH2M HILL subcontractors is available.
- Request or confirm locations of Material Safety Data Sheets (MSDSs) from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed.
- Before or as the chemicals arrive on site, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly.
- Give employees required chemical-specific HAZCOM training using Attachment 3.
- Store all materials properly, giving consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

C.2.2.3 Shipping and Transportation of Chemical Products

(Reference CH2M HILL's *Procedures for Shipping and Transporting Dangerous Goods)*

Chemicals brought to the site might be defined as hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the HSM or the Equipment Coordinator for additional information.

C.2.2.4 Lifting

(Reference CH2M HILL SOP HS-29, *Lifting)*

- Proper lifting techniques must be used when lifting any object.
  - Plan storage and staging to minimize lifting or carrying distances.
  - Split heavy loads into smaller loads.
  - Use mechanical lifting aids whenever possible.

- Have someone assist with the lift -- especially for heavy or awkward loads.
- Make sure the path of travel is clear prior to the lift.

C.2.2.5 Fire Prevention

(Reference CH2M HILL SOP HS-22, *Fire Prevention*)

- Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet. When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet. Extinguishers must:
  - be maintained in a fully charged and operable condition,
  - be visually inspected each month, and
  - undergo a maintenance check each year.
- The area in front of extinguishers must be kept clear.
- Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet from any building.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

C.2.2.6 Electrical

(Reference CH2M HILL SOP HS-23, *Electrical*)

- Only qualified personnel are permitted to work on unprotected energized electrical systems.
- Only authorized personnel are permitted to enter high-voltage areas.
- Do not tamper with electrical wiring and equipment unless qualified to do so. All electrical wiring and equipment must be considered energized until lockout/tagout procedures are implemented.
- Inspect electrical equipment, power tools, and extension cords for damage prior to use. Do not use defective electrical equipment, remove from service.
- All temporary wiring, including extension cords and electrical power tools, must have ground fault circuit interrupters (GFCIs) installed.
- Extension cords must be:
  - equipped with third-wire grounding.
  - covered, elevated, or protected from damage when passing through work areas.
  - protected from pinching if routed through doorways.
  - not fastened with staples, hung from nails, or suspended with wire.
- Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.

- Operate and maintain electric power tools and equipment according to manufacturers' instructions.
- Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet from overhead power lines for voltages of 50 kV or less, and 10 feet plus ½ inch for every 1 kV over 50 kV.
- Temporary lights shall not be suspended by their electric cord unless designed for suspension. Lights shall be protected from accidental contact or breakage.
- Protect all electrical equipment, tools, switches, and outlets from environmental elements.

C.2.2.7 Stairways and Ladders

(Reference CH2M HILL SOP HS-25, *Stairways and Ladders*)

- Stairway or ladder is generally required when a break in elevation of 19 inches or greater exists.
- Personnel should avoid using both hands to carry objects while on stairways; if unavoidable, use extra precautions.
- Personnel must not use pan and skeleton metal stairs until permanent or temporary treads and landings are provided the full width and depth of each step and landing.
- Ladders must be inspected by a competent person for visible defects prior to each day's use. Defective ladders must be tagged and removed from service.
- Ladders must be used only for the purpose for which they were designed and shall not be loaded beyond their rated capacity.
- Only one person at a time shall climb on or work from an individual ladder.
- User must face the ladder when climbing; keep belt buckle between side rails
- Ladders shall not be moved, shifted, or extended while in use.
- User must use both hands to climb; use rope to raise and lower equipment and materials
- Straight and extension ladders must be tied off to prevent displacement
- Ladders that may be displaced by work activities or traffic must be secured or barricaded
- Portable ladders must extend at least 3 feet above landing surface
- Straight and extension ladders must be positioned at such an angle that the ladder base to the wall is one-fourth of the working length of the ladder
- Stepladders are to be used in the fully opened and locked position
- Users are not to stand on the top two steps of a stepladder; nor are users to sit on top or straddle a stepladder

- Fixed ladders ≥ 24 feet in height must be provided with fall protection devices.
- Fall protection should be considered when working from extension, straight, or fixed ladders greater than six feet from lower levels and both hands are needed to perform the work, or when reaching or working outside of the plane of ladder side rails.

C.2.2.8 Heat Stress

(Reference CH2M HILL SOP HS-09, *Heat and Cold Stress*)

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50°F to 60°F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (e.g., do not begin with extremely demanding activities).
- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Avoid direct sun whenever possible, which can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.
- Provide adequate shelter/shade to protect personnel against radiant heat (sun, flames, hot metal).
- Maintain good hygiene standards by frequently changing clothing and showering.
- Observe one another for signs of heat stress. Persons who experience signs of heat syncope, heat rash, or heat cramps should consult the SSC/DSC to avoid progression of heat-related illness.

SYMPTOMS AND TREATMENT OF HEAT STRESS					
	Heat Syncope	Heat Rash	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler	Use mild drying	Remove to cooler	Remove to cooler area.	Cool rapidly by

SYMPTOMS AND TREATMENT OF HEAT STRESS					
	area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	lotions and powders, and keep skin clean for drying skin and preventing infection.	area. Rest lying down. Increase fluid intake.	Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	soaking in cool– but not cold–water. Call ambulance, and get medical attention immediately!

Monitoring Heat Stress

These procedures should be considered when the ambient air temperature exceeds 70°F, the relative humidity is high (>50 percent), or when workers exhibit symptoms of heat stress. The heart rate (HR) should be measured by the radial pulse for 30 seconds, as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 100 beats/minute, or 20 beats/minute above resting pulse. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 100 beats/minute at the beginning of the next rest period, the work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 100 beats/minute, or 20 beats/minute above resting pulse.

C.2.2.9 Cold Stress

(Reference CH2M HILL SOP HS-09, *Heat and Cold Stress*)

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in cool weather.
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- Wind-Chill Index is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it should only be used as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.
- NSC Guidelines for Work and Warm-Up Schedules can be used with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; workers should be monitored for symptoms of cold-related illnesses. If symptoms are not observed, the work duration can be increased.
- Persons who experience initial signs of immersion foot, frostbite, hypothermia should consult the SSC/DSC to avoid progression of cold-related illness.
- Observe one another for initial signs of cold-related disorders.
- Obtain and review weather forecast – be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

SYMPTOMS AND TREATMENT OF COLD STRESS			
	Immersion (Trench) Foot	**Frostbite**	**Hypothermia**
Signs and	Feet discolored and	Blanched, white, waxy skin, but tissue	Shivering, apathy, sleepiness;

Symptoms	painful; infection and swelling present.	resilient; tissue cold and pale.	rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Re-warm area quickly in warm–but **not** hot–water. Have victim drink warm fluids, but **not** coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.

C.2.2.10 Compressed Gas Cylinders

- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured in an upright position at all times.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over; contacting electrical circuits; or exposed to extreme heat sources.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.

C.2.2.11 Procedures for Locating Buried Utilities

Local Utility Mark-Out Service

Name: NC Call One
Phone: 1-800-632-4949

- Where available, obtain utility diagrams for the facility.
- Review locations of sanitary and storm sewers, electrical conduits, water supply lines, natural gas lines, and fuel tanks and lines.
- Review proposed locations of intrusive work with facility personnel knowledgeable of locations of utilities. Check locations against information from utility mark-out service.
- Where necessary (e.g., uncertainty about utility locations), excavation or drilling of the upper depth interval should be performed manually
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change n advancement of auger or split spoon).
- When the client or other onsite party is responsible for determining the presence and locations of buried utilities, the SSC should confirm that arrangement.

C.2.2.12 Confined Space Entry

(Reference CH2M HILL SOP HS-17, *Confined Space Entry*)

No confined space entry will be permitted. Confined space entry requires additional health and safety procedures, training, and a permit. If conditions change such that confined-space entry is necessary, contact the HSM to develop the required entry permit.
When planned activities will not include confined-space entry, permit-required confined spaces accessible to CH2M HILL personnel are to be identified before the task begins. The SSC is to confirm that permit spaces are properly posted or that employees are informed of their locations and hazards.

C.2.3 Biological Hazards and Controls

C.2.3.1 Snakes

Snakes typically are found in underbrush and tall grassy areas. If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If a person is bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Seek medical attention immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Try to identify the type of snake: note color, size, patterns, and markings.

C.2.3.2 Poison Ivy and Poison Sumac

Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas. Become familiar with the identity of these plants. Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.

C.2.3.3 Ticks

Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size. Wear tightly woven light-colored clothing with long sleeves and pant legs tucked into boots; spray **only outside** of clothing with permethrin or permanone and spray skin with only DEET; and check yourself frequently for ticks.

If bitten by a tick, grasp it at the point of attachment and carefully remove it. After removing the tick, wash your hands and disinfect and press the bite areas. Save the removed tick. Report the bite to human resources. Look for symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme: a rash might appear that looks like a bullseye with a small welt in the center. RMSF: a rash of red spots under the skin 3 to 10 days after the tick bite. In both cases, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, seek medical attention.

C.2.3.4 Bees and Other Stinging Insects

Bee and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SSC

and/or buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops.

C.2.3.5 Bloodborne Pathogens

(Reference CH2M HILL SOP HS-36, *Bloodborne Pathogens*)

Exposure to bloodborne pathogens may occur when rendering first aid or CPR, or when coming into contact with landfill waste or waste streams containing potentially infectious material. Exposure controls and personal protective equipment (PPE) are required as specified in CH2M HILL SOP HS-36, *Bloodborne Pathogens*. Hepatitis B vaccination must be offered before the person participates in a task where exposure is a possibility.

C.2.3.6 Other Anticipated Biological Hazards

None are anticipated

C.2.4 Radiological Hazards and Controls

Refer to CH2M HILL's *Corporate Health and Safety Program, Program and Training Manual,* and *Corporate Health and Safety Program, Radiation Protection Program Manual,* for standards of practice in contaminated areas.

Hazards	Controls
None Known	None Required

C.2.5 Contaminants of Concern

(Refer to Project Files for more detailed contaminant information)

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
1,1-Dichloroethane	GW:0.6 J SB: SS:	100 ppm	3,000	CNS depression, skin irritation; liver, kidney, and lung damage	11.06
1,1- Dichloroethene	GW:53 SB: SS:	1 ppm	50 ppm	Suspected human carcinogen, irritated eyes, kidney and live damage, CNS depression.	10.00
Cis-1,2-Dichloroethene	GW:84,000 D SB: SS:	NA	NA	Irritating to eyes, respiratory system and skin. Target organs include CNS and liver.	
Trans-1,2-Dichloroethene	GW:150 SB: SS:	NA	NA	Irritating to eyes, respiratory system and skin. Target organs include CAN, liver, and kidneys.	
Tetrachloroethylene (PCE)	GW:20,000 D SB: SS:	25 ppm	150 Ca	Eye, nose, and throat irritation; nausea; flushed face and neck; vertigo; dizziness; sleepiness; skin redness; headache; liver damage	9.32
1,1,2-Trichloroethane	GW:12,000 D SB: SS:	10 ppm	100 Ca	Eye and nose irritation, CNS depression, liver damage, dermatitis	11.00
Trichloroethylene (TCE)	GW:2,600 JD SB: SS:	50 ppm	1,000 Ca	Headache, vertigo, visual disturbance, eye and skin irritation, fatigue, giddiness, tremors, sleepiness, nausea, vomiting, dermatitis, cardiac arrhythmia, paresthesia, liver injury	9.45
Vinyl Chloride	GW:45,000 D SB: SS:	1 ppm	NL Ca	Weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or cyanosis of extremities	9.99

Footnotes:

[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), S (Surface Soil), SL (Sludge), SW (Surface Water).

[b] Appropriate value of PEL, REL, or TLV listed.

[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.

[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

C.2.5 Contaminants of Concern

(Refer to Project Files for more detailed contaminant information)

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)

C.2.6 Potential Routes of Exposure

Dermal: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 4.	**Inhalation:** Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in Sections 4 and 5, respectively.	**Other:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

C.3 Project Organization and Personnel

C.3.1 CH2M HILL Employee Medical Surveillance and Training

(Reference CH2M HILL SOPs HS-01, *Medical Surveillance,* and HS-02, *Health and Safety Training)*

The employees listed below are enrolled in the CH2M HILL Comprehensive Health and Safety Program and meet state and federal hazardous waste operations requirements for 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training. Employees designated "SSC" have completed a 12-hour site safety coordinator course, and have documented requisite field experience. An SSC with a level designation (D, C, B) equal to or greater than the level of protection being used must be present during all tasks performed in exclusion or decontamination zones. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. At least one FA-CPR designated employee must be present during all tasks performed in exclusion or decontamination zones. The employees listed below are currently active in a medical surveillance program that meets state and federal regulatory requirements for hazardous waste operations. Certain tasks (e.g., confined-space entry) and contaminants (e.g., lead) may require additional training and medical monitoring.

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL's SOP HS-04, *Reproduction Protection,* including obtaining a physician's statement of the employee's ability to perform hazardous activities before being assigned fieldwork.

Employee Name	Office	Responsibility	SSC/FA-CPR
Teg Williams	CLT	Task Manager	Level C SSC, FA-CPR
Dan Tomczak	RDU	Field Team Leader/ Site Safety Coordinator	Level C SSC
Jeremy Vaughan	CLT	Field Team Leader/ Site Safety Coordinator	Level C SSC, FA-CPR

C.3.2 Field Team Chain of Command and Communication Procedures

C.3.2.1 Client

Client Contact
Kirk Stevens, PE
LANTDIV
Code: EV23
1510 Gilbert St., Building N26

Base Contact
Rick Raines
Camp Lejeune - EMD
Building 58
Marine Corps Base

Norfolk, Virginia 23511-2699
757-322-8422
757-322-4805 fax
stevenska@efdlant.navfac.navy.mil

Camp Lejeune, NC 28542-0004
(910) 451-9461
(910) 451-5997
rainesrh@lejeune.usmc.mil

C.3.2.2 CH2M HILL

Project Manager: Chris Bozzini/CLT
Health and Safety Manager: Mike Goldman/ATL
Field Team Leader: Dan Tomczak/RDU, Jeremy Vaughan/CLT
Site Safety Coordinator: Dan Tomczak/RDU, Jeremy Vaughan/CLT
The SSC is responsible for contacting the Field Team Leader and Project Manager. In general, the Project Manager will contact the client. The Health and Safety Manager should be contacted as appropriate.

C.3.2.3 CH2M HILL Subcontractors

(Reference CH2M HILL SOP HS-55, *Subcontractor, Contractor, and Owner*)

Subcontractor: TBD
Subcontractor Contact Name: TBD
Telephone: TBD

The subcontractors listed above are covered by this HSP and must be provided a copy of this plan. However, this plan does not address hazards associated with the tasks and equipment that the subcontractor has expertise in (e.g., drilling, excavation work, electrical). Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit these procedures to CH2M HILL for review before the start of field work. Subcontractors must comply with the established health and safety plan(s). The CH2M HILL SSC should verify that subcontractor employee training, medical clearance, and fit test records are current and must monitor and enforce compliance with the established plan(s). CH2M HILL's oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

CH2M HILL should continuously endeavor to observe subcontractors' safety performance. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. In addition to this level of observation, the SSC is responsible for confirming CH2M HILL subcontractor performance against both the subcontractor's safety plan and applicable self-assessment checklists. Self-assessment checklists contained in Attachment 6 are to be used by the SSC to review subcontractor performance.

Health and safety related communications with CH2M HILL subcontractors should be conducted as follows:

- Brief subcontractors on the provisions of this plan, and require them to sign the Employee Signoff Form included in Attachment 1.
- Request subcontractor(s) to brief the project team on the hazards and precautions related to their work.
- When apparent non-compliance/unsafe conditions or practices are observed, notify the subcontractor safety representative and require corrective action – the subcontractor is responsible for determining and implementing necessary controls and corrective actions.

- When repeat non-compliance/unsafe conditions are observed, notify the subcontractor safety representative and stop affected work until adequate corrective measures are implemented.
- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor safety representative, and stop affected work until adequate corrective measures are implemented. Notify the Project Manager and HSM as appropriate.
- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

C.3.2.4 Contractors

(Reference CH2M HILL SOP HS-55, *Subcontractor, Contractor, and Owner*)

Contractor: TBD
Contractor Contact Name: TBD
Telephone: TBD

This plan does not cover contractors that are contracted directly to the client or the owner. CH2M HILL is not responsible for the health and safety or means and methods of the contractor's work, and we must never assume such responsibility through our actions (e.g., advising on H&S issues). In addition to this plan, CH2M HILL staff should review contractor safety plans so that we remain aware of appropriate precautions that apply to us. Except in unusual situations when conducted by the HSM, CH2M HILL must never comment on or approve contractor safety procedures. Self-assessment checklists contained in Attachment 6 are to be used by the SSC to review the contractor's performance ONLY as it pertains to evaluating our exposure and safety.

Health and safety related communications with contractors should be conducted as follows:

- Request the contractor to brief CH2M HILL employees and subcontractors on the precautions related to the contractor's work.
- When an apparent contractor non-compliance/unsafe condition or practice poses a risk to CH2M HILL employees or subcontractors:
  - Notify the contractor safety representative
  - Request that the contractor determine and implement corrective actions
  - If needed, stop affected CH2M HILL work until contractor corrects the condition or practice. Notify the client, Project Manager, and HSM as appropriate.
- If apparent contractor non-compliance/unsafe conditions or practices are observed, inform the contractor safety representative. Our obligation is limited strictly to informing the contractor of our observation – the contractor is solely responsible for determining and implementing necessary controls and corrective actions.
- If an apparent imminent danger is observed, immediately warn the contractor employee(s) in danger and notify the contractor safety representative. Our obligation is limited strictly to immediately warning the affected individual(s) and informing the contractor of our observation – the contractor is solely responsible for determining and implementing necessary controls and corrective actions.
- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

C.4 Personal Protective Equipment (PPE)

(Reference CH2M HILL SOP HS-07, *Personal Protective Equipment*, HS-08, *Respiratory Protection*)

PPE Specifications [a]

Task	Level	Body	Head	Respirator [b]
General site entry Surveying Observation of material loading for offsite disposal Oversight of remediation and construction	D	Work clothes; steel-toe, leather work boots; work glove.	Hardhat [c] Safety glasses Ear protection [d]	None required
Surface water sampling Aquifer testing Sediment sampling Surface soil sampling Hand augering Geoprobe boring	Modified D	Work clothes or cotton coveralls **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Safety glasses Ear protection [d]	None required
Groundwater sampling Soil boring Investigation-derived waste (drum) sampling and disposal	Modified D	**Coveralls:** Uncoated Tyvek® **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Safety glasses Ear protection [d]	None required.
Tasks requiring upgrade	C	**Coveralls:** Polycoated Tyvek® **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H cartridges or equivalent[e].

Reasons for Upgrading or Downgrading Level of Protection

Upgrade[f]	Downgrade
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 5) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

[a] Modifications are as indicated. CH2M HILL will provide PPE only to CH2M HILL employees.

[b] No facial hair that would interfere with respirator fit is permitted.

[c] Hardhat and splash-shield areas are to be determined by the SSC.

[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet or less without shouting.

[e] Cartridge change-out schedule is at least every 8 hours (or one work day), except if relative humidity is > 85%, or if organic vapor measurements are > midpoint of Level C range (refer to Section 5)--then at least every 4 hours. If encountered conditions are different than those anticipated in this HSP, contact the HSM.

[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the HSM, and an SSC qualified at that level is present.

C.5 Air Monitoring/Sampling

(Reference CH2M HILL SOP HS-06, *Air Monitoring)*

C.5.1 Air Monitoring Specifications

Instrument	Tasks	Action Levels[a]		Frequency [b]	Calibration
FID: TVA model 1000 or equivalent	All intrusive work	>1 ppm 1 to 25 ppm 25 ppm	Level D Level C. Collect colorimetric tube samples for Vinyl Chloride Evacuate Site and contact HSM	Initially and periodically during task	Daily
PID: Mini-RAE with 10.6eV lamp or equivalent	All intrusive work	>1 ppm 1 to 25 ppm 25 ppm	Level D Level C. Collect colorimetric tube samples for Vinyl Chloride. Evacuate Site and contact HSM	Initially and periodically during task	Daily
CGI: MSA model 260 or 261 or equivalent	All intrusive work	0-10% : 10-25% LEL: >25% LEL:	No explosion hazard Potential explosion hazard Explosion hazard; evacuate or vent	Continuous during advancement of boring or trench	Daily
O_2Meter: MSA model 260 or 261 or equivalent	All intrusive work	>25%[c] O_2: 20.9%[c] O_2: <19.5%[c] O_2:	Explosion hazard; evacuate or vent Normal O_2 O_2 deficient; vent or use SCBA	Continuous during advancement of boring or trench	Daily
Colormetric Tube: Drager vinyl chloride specific (0.5 to 30 ppm range) with pre-tube, or equivalent and PCE specific (2 to 300 ppm range).	If PID/FID indicates readings above 1 ppm	<0.5 ppm 0.5 ppm	Level D Evacuate site and contact HSM	Initially and periodically when PID/FID >1 ppm	Not applicable

[a] Action levels apply to sustained breathing-zone measurements above background.

[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SSC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate. Monitoring results should be recorded. Documentation should include instrument and calibration information, time, measurement results, personnel monitored, and place/location where measurement is taken (e.g., "Breathing Zone/MW-3", "at surface/SB-2", etc.).

[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry (refer to Section 2).

[d] Refer to SOP HS-10 for instructions and documentation on radiation monitoring and screening.

[e] Noise monitoring and audiometric testing also required.

C.5.2 Calibration Specifications

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
PID: OVM, 10.6 or 11.8 eV bulb	100 ppm isobutylene	RF = 1.0	100 ppm	1.5 lpm reg T-tubing
PID: MiniRAE, 10.6 eV bulb	100 ppm isobutylene	CF = 100	100 ppm	1.5 lpm reg T-tubing
PID: TVA 1000	100 ppm isobutylene	CF = 1.0	100 ppm	1.5 lpm reg T-tubing
FID: OVA	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 lpm reg T-tubing
FID: TVA 1000	100 ppm methane	NA	100 ppm	2.5 lpm reg T-tubing
CGI: MSA 260, 261, 360, or 361	0.75% pentane	N/A	50% LEL ± 5% LEL	1.5 lpm reg direct tubing

C.5.3 Air Sampling

Sampling, in addition to real-time monitoring, may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the HSM immediately if these contaminants are encountered.

Method Description

Vinyl chloride – NIOSH Method #1015 may be utilized if elevated levels of vinyl chloride are found.

Personnel and Areas

Results must be sent immediately to the HSM. Regulations may require reporting to monitored personnel. Results reported to:

HSM: Michael Goldman/ATL

C.6 Decontamination

(Reference CH2M HILL SOP HS-13, *Decontamination*)

The SSC must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SSC. The SSC must ensure that procedures are established for disposing of materials generated on the site.

C.6.1 Decontamination Specifications

Personnel

- Boot wash/rinse
- Glove wash/rinse
- Outer-glove removal
- Body-suit removal
- Inner-glove removal
- Respirator removal
- Hand wash/rinse
- Face wash/rinse
- Shower ASAP
- Dispose of PPE in municipal trash, or contain for disposal
- Dispose of personnel rinse water to facility or sanitary sewer, or contain for offsite disposal

Sample Equipment

- Wash/rinse equipment
- Solvent-rinse equipment
- Contain solvent waste for offsite disposal

Heavy Equipment

- Power wash
- Steam clean
- Dispose of equipment rinse water to facility or sanitary sewer, or contain for offsite disposal

C.6.2 Diagram of Personnel-Decontamination Line

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SSC should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

Figure C-6-1 illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SSC to accommodate task-specific requirements.

C.7 Spill-Containment Procedures

Sorbent material will be maintained in the support zone. Incidental spills will be contained with sorbent and disposed of properly.

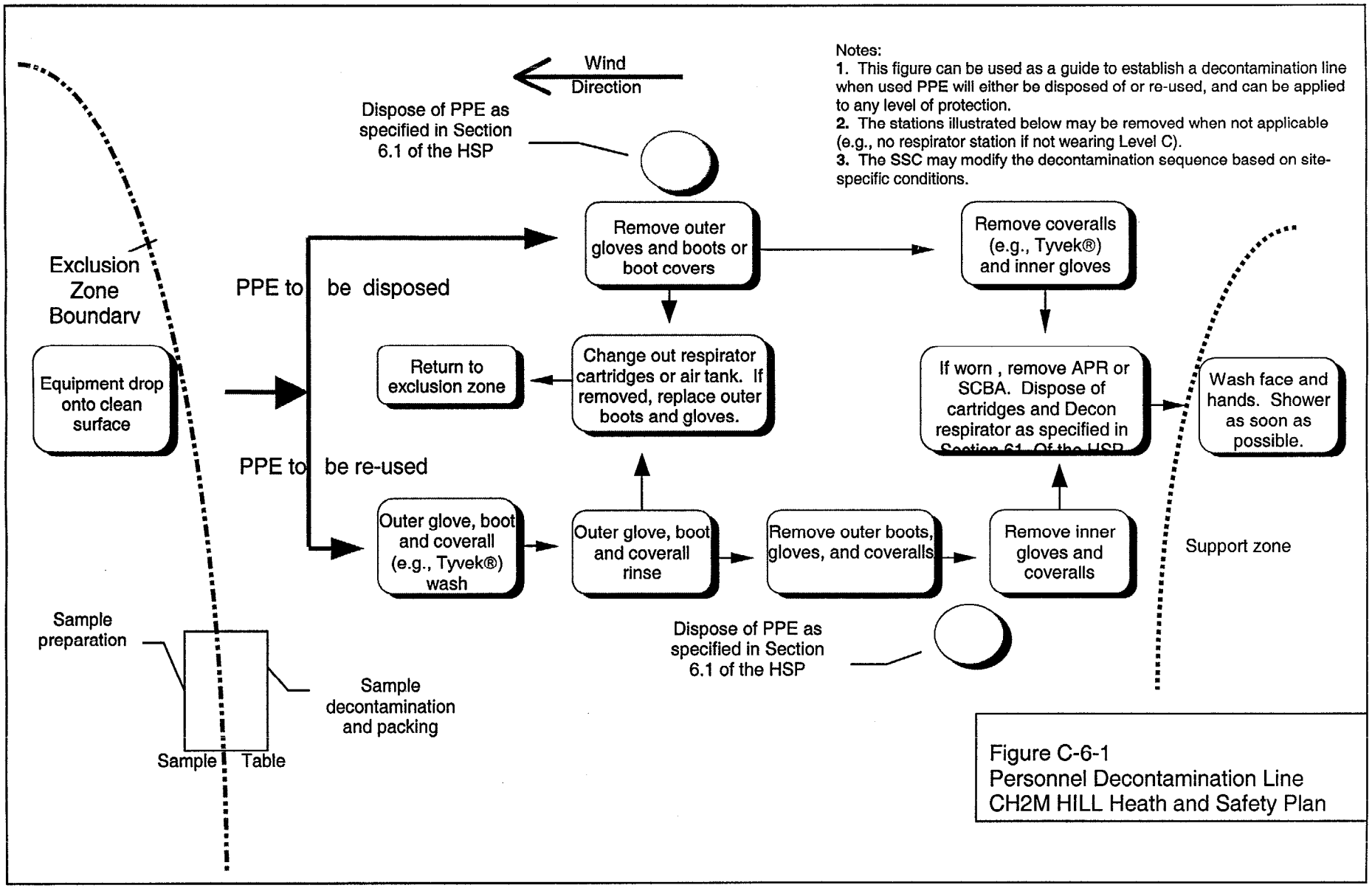

Figure C-6-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

C.8 Site-Control Plan

C.8.1 Site-Control Procedures

(Reference CH2M HILL SOP HS-11, *Site Control)*

- The SSC will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing on site safety: general discussion of Health and Safety Plan, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies.
- The SSC records attendance at safety briefings in a logbook and documents the topics discussed.
- Post the OSHA job-site poster in a central and conspicuous location in accordance with CH2M HILL SOP HS-71, *OSHA Postings*.
- Establish support, decontamination, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals
  - Air horn
  - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the "buddy system."
- Initial air monitoring is conducted by the SSC in appropriate level of protection.
- The SCC is to conduct periodic inspections of work practices to determine the effectiveness of this plan – refer to Sections 2 and 3. Deficiencies are to be noted, reported to the HSM, and corrected.

C.8.2 Hazwoper Compliance Plan

(Reference CH2M HILL SOP HS-19, *Site-Specific Written Safety Plans)*

Certain parts of the site work are covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated Hazwoper tasks (Section 1.1.1) might occur consecutively or concurrently with respect to non-Hazwoper tasks. This section outlines procedures to be followed when approved activities specified in Section 1.1.2 do not require 24- or 40-hour training. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements.

- In many cases, air sampling, in addition to real-time monitoring, must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site, or while non-Hazwoper-trained staff are working in proximity to Hazwoper activities. Other data (e.g., soil) also must document that there is no potential for exposure. The HSM must approve the interpretation of these data. Refer to subsections 2.5 and 5.3 for contaminant data and air sampling requirements, respectively.

- When non-Hazwoper-trained personnel are at risk of exposure, the SSC must post the exclusion zone and inform non-Hazwoper-trained personnel of the:
  - nature of the existing contamination and its locations
  - limitations of their access
  - emergency action plan for the site
- Periodic air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to airborne contaminants.
- When exposure is possible, non-Hazwoper-trained personnel must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.
- Remediation treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is, for the purposes of applying the Hazwoper standard, considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hour of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must not enter the TSDF area of the site.

C.9 Emergency Response Plan

(Reference CH2M HILL, SOP HS-12, *Emergency Response*)

C.9.1 Pre-Emergency Planning

The SSC performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M HILL onsite parties, the facility, and local emergency-service providers as appropriate.

- Review the facility emergency and contingency plans where applicable.
- Determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Determine what offsite communication equipment is needed (e.g., nearest telephone, cell phone).
- Confirm and post emergency telephone numbers, evacuation routes, assembly areas, and route to hospital; communicate the information to onsite personnel.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases.
- Rehearse the emergency response plan before site activities begin, including driving route to hospital.
- Brief new workers on the emergency response plan.

The SSC will evaluate emergency response actions and initiate appropriate follow-up actions.

C.9.2 Emergency Equipment and Supplies

The SSC should mark the locations of emergency equipment on the site map and post the map.

Emergency Equipment and Supplies	Location

20 LB (or two 10-lb) fire extinguisher (A, B, and C classes)	Support Zone/Heavy Equipment
First aid kit	Support Zone/Field Vehicle
Eye Wash	Support & Decon Zone/Field Vehicle
Potable water	Support & Decon Zone/Field Vehicle
Bloodborne-pathogen kit	Support Zone/Field Vehicle
Additional equipment (specify):	

C.9.3 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Shut down CH2M HILL operations and evacuate the immediate work area.
- Notify appropriate response personnel.
- Account for personnel at the designated assembly area(s).
- Assess the need for site evacuation, and evacuate the site as warranted.

Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled.

C.9.4 Emergency Medical Treatment

The procedures listed below may also be applied to non-emergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the CH2M HILL medical consultant. During non-emergencies, follow these procedures as appropriate.

- Notify appropriate emergency response authorities listed in Section 9.8 (e.g., 911).
- The SCC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first aid and CPR where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible; lifesaving and first aid or medical treatment take priority.
- Make certain that the injured person is accompanied to the emergency room.
- When contacting the medical consultant, state that the situation is a CH2M HILL matter, and give your name and telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.
- Report incident as outlined in Section 9.7.

C.9.5 Evacuation

- Evacuation routes and assembly areas (and alternative routes and assembly areas) are specified on the site map.
- Evacuation route(s) and assembly area(s) will be designated by the SSC before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.
- The SSC will account for all personnel in the onsite assembly area.
- A designated person will account for personnel at alternate assembly area(s).
- The SSC will write up the incident as soon as possible after it occurs and submit a report to the Corporate Director of Health and Safety.

C.9.6 Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

C.9.7 Incident Notification and Reporting

- Upon any project incident (fire, spill, injury, near miss, death, etc.), immediately notify the PM and HSM. Call emergency beeper number if HSM is unavailable.
- For CH2M HILL work-related injuries or illnesses, contact and help Human Resources administrator complete an Incident Report Form (IRF). IRF must be completed within 24 hours of incident.
- For CH2M HILL subcontractor incidents, complete the Subcontractor Accident/Illness Report Form and submit to the HSM.
- Notify and submit reports to client as required in contract.

C.10 Approval

This site-specific Health and Safety Plan has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

C.10.1 Original Plan

Written By: Jeremy Vaughan **Date: January 7, 2003**

Approved By: **Date:**

C.10.2 Revisions

Revisions Made By: **Date:**

Revisions to Plan:

Revisions Approved By: **Date:**

C.11 Attachments

Attachment 1	Employee Signoff Form – Field Safety Instructions
Attachment 2	Project-Specific Chemical Product Hazard Communication Form
Attachment 3	Chemical-Specific Training Form
Attachment 4	Emergency Contacts
Attachment 5	Project H&S Forms/Permits
Attachment 6	Project Activity Self-Assessment Checklists
Attachment 7	Applicable Material Safety Data Sheets
Attachment 8	Incident Report Forms

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 1

Employee Signoff Form – Field Safety Instructions

CH2MHILL

EMPLOYEE SIGNOFF FORM

Health and Safety Plan

- The CH2M HILL project employees and subcontractors listed below have been provided with a copy of this HSP, have read and understood it, and agree to abide by its provisions.

Project Name: Camp Lejeune, O.U. 15, Site 88 **Project Number:** 174056

EMPLOYEE NAME (Please print)	EMPLOYEE SIGNATURE	COMPANY	DATE

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 2

Project-Specific Chemical Product Hazardous Communication Form

CH2MHILL

Project-Specific Chemical Product Hazard Communication Form

This form must be completed prior to performing activities that expose personnel to hazardous chemicals products. Upon completion of this form, the SSC shall verify that training is provided on the hazards associated with these chemicals and the control measures to be used to prevent exposure to CH2M HILL and subcontractor personnel. Labeling and MSDS systems will also be explained.

Project Name: Camp Lejeune, O.U. 15, Site 88 **Project Number:** 174056

MSDSs will be maintained at the following location(s):

Hazardous Chemical Products Inventory

Chemical	*Quantity*	Location	MSDS Available	*Container labels* Identity	Hazard
Methane	1 liter, compressed	Support Zone			
Isobutylene	1 liter, compressed	Support Zone			
Pentane	1 liter, compressed	Support Zone			
Hydrochloric acid	< 500 ml	Support Zone / sample bottles			
Nitric acid	< 500 ml	Support Zone / sample bottles			
Sulfuric Acid	< 500 ml	Support Zone / sample bottles			
Sodium hydroxide	< 500 ml	Support Zone / sample bottles			
Methanol	< 1 Gallon	Support/Decon Zones			
Isopropanol	< 1 Gallon	Support/Decon Zones			
pH buffers	< 500 ml	Support Zone			
MSA Sanitizer	< 1 liter	Support/Decon Zones			
Alconox/Liquinox	< 1 liter	Support/Decon Zones			

Refer to SOP HS-05 *Hazard Communication* for more detailed information.

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 3

Chemical-Specific Training Form

CH2MHILL

CHEMICAL-SPECIFIC TRAINING FORM

Location:	Project # : 174056
HCC:	Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product MSDS to provide the following information concerning each of the products listed above.

☐ Physical and health hazards

☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)

☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of MSDSs, chemical inventories, and CH2M HILL's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 4

Emergency Contacts

Emergency Contacts

24-hour CH2M HILL Emergency Beeper – 888/444-1226

Medical Emergency – 911

Hospital ER (On-Base) #: (910) 451-4840
(910) 451-4841
(910) 451-4842

Onslow County ER (Off-Base) #: (910) 577-2240

Ambulance (On-Base) #: (910) 451-3004
(910) 451-3005

Ambulance (Public) #: (910) 451-9111

CH2M HILL Medical Consultant

Dr. Peter Greaney
GMG WorkCare, Orange, CA
800/455-6155
(After hours calls will be returned within 20 minutes)

Fire/Spill Emergency -- 911

Base Fire Response #: (910) 451-9111

Local Occupational Physician

Security & Police – 911

Base Security #: (910) 451-2555

Corporate Director Health and Safety

Name: Mollie Netherland/SEA
Phone: 206/453-5005
24-hour emergency beeper: 888-444-1226

Utilities Emergency

Water:
Gas:
Electric:

Health and Safety Manager (HSM)

Name:
Phone:

Designated Safety Coordinator (DSC)

Name:
Phone:

Regional Human Resources Department

Name:
Phone:

Project Manager

Name: Chris Bozzini/CLT
Phone: (704) 329-0073 x291
Name: Scott Bailey/VBO
Phone: (757) 460-3734 x 23
Home: (757) 538-3245
Cell: (757) 635-2357

Corporate Human Resources Department

Name: John Monark/COR
Phone: 303/771-0900

Federal Express Dangerous Goods Shipping

Phone: 800/238-5355

CH2M HILL Emergency Number for Shipping Dangerous Goods

Phone: 800/255-3924

Worker's Compensation and Auto Claims

Sterling Administration Services
Phone: 800/420-8926 After hours: 800/497-4566

Report fatalities AND report vehicular accidents involving pedestrians, motorcycles, or more than two cars.

Contact the Project Manager. Generally, the Project Manager will contact relevant government agencies.

Facility Alarms: **Evacuation Assembly Area(s):**

Facility/Site Evacuation Route(s):

Hospital Name/Address: Onslow County Memorial Hospital 317 Western Boulevard **Hospital Phone #:** (910) 577-2240

Directions to Hospital

From MCB Camp Lejeune

Directions to the Base Naval Hospital (Building NH100)
(nearest hospital; only to be used in an extreme emergency)

1. Proceed north to Holcomb Boulevard (towards Highway 24).
2. Turn left onto Brewster Boulevard (heading west)
3. Continue on Brewster Boulevard until intersection with the driveway to the Naval Hospital.
4. Turn onto Hospital driveway, and proceed to emergency room.

Directions to Onslow County Memorial Hospital :

1. From Holcomb Boulevard, exit Base through main gate.
2. Follow Highway 24 west until intersecting with Western Boulevard.
3. Turn right onto Western Boulevard.
4. The Onslow County Memorial Hospital is on the left, approximately 2 miles (fifth stoplight) from Highway 24.
5. Follow the signs to the emergency room.

From Air Station and Camp Geiger

Directions to Onslow County Memorial Hospital:

1. Proceed through the main gate, turn right, and head north on Ocean Highway 17.
2. Follow Ocean Highway 17 north to Highway 24 and head east.
3. Travel east until Western Boulevard, turn left onto Western Boulevard.
4. The Onslow County Memorial Hospital is on the left, approximately 2 miles (fifth stoplight) from Highway 24.
5. Follow the signs to the emergency room.

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 5

Project H&S Forms and Permits

Attachment 5

Project #	Project Name						Number of Containers	Analyze For					Remarks
Samplers: (Signature)													
Sample #	Date	Time	Type	Comp	Grab	Sample Location							
Relinquished By:			Date:	Time:	Received By:		Relinquished By:				Date:	Time	Received By:
Relinquished By:			Date:	Time:	Received for Lab By:		Date	Time	Remarks				
Handling Instructions:													Turnaround Time:
Instructions													

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 6

Project Activity Self-Assessment Checklists

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to hazards associated with drilling operations (complete Sections 1 and 3), and/or 2) CH2M HILL oversight of a drilling subcontractor is required (complete entire checklist).

SSC/DSC may consult with drilling subcontractors when completing this checklist, but shall not direct the means and methods of drilling operations nor direct the details of corrective actions. Drilling subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Completed checklists shall be sent to the health and safety manager for review.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to drilling hazards

☐ Evaluate a CH2M HILL subcontractor's compliance with drilling H&S requirements

Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the drilling subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HS-35.

SECTION 1	Yes	No	N/A	N/O
PERSONNEL SAFE WORK PRACTICES (3.1)				
1. Only authorized personnel operating drill rig	☐	☐	☐	☐
2. Personnel cleared during rig startup	☐	☐	☐	☐
3. Personnel clear of rotating parts	☐	☐	☐	☐
4. Personnel not positioned under hoisted loads	☐	☐	☐	☐
5. Loose clothing and jewelry removed	☐	☐	☐	☐
6. Personnel instructed not to approach equipment that has become electrically energized	☐	☐	☐	☐
7. Smoking is prohibited around drilling operation	☐	☐	☐	☐
8. Personnel wearing appropriate PPE, per HSP/FSI	☐	☐	☐	☐

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SECTION 2	Yes	No	N/A	N/O
GENERAL (3.2.1)				
9. Daily safety briefing/meeting conducted with crew	☐	☐	☐	☐
10. Daily inspection of drill rig and equipment conducted before use	☐	☐	☐	☐
DRILL RIG PLACEMENT (3.2.2)				
11. Location of underground utilities identified	☐	☐	☐	☐
12. Safe clearance distance maintained from overhead powerlines	☐	☐	☐	☐
13. Drilling pad established, when necessary	☐	☐	☐	☐
14. Drill rig leveled and stabilized	☐	☐	☐	☐
DRILL RIG TRAVEL (3.2.3)				
15. Rig shut down and mast lowered and secured prior to rig movement	☐	☐	☐	☐
16. Tools and equipment secured prior to rig movement	☐	☐	☐	☐
17. Only personnel seated in cab are riding on rig during movement	☐	☐	☐	☐
18. Safe clearance distance maintained while traveling under overhead powerlines	☐	☐	☐	☐
19. Backup alarm or spotter used when backing rig	☐	☐	☐	☐
DRILL RIG OPERATION (3.2.4)				
20. Kill switch clearly identified and operational	☐	☐	☐	☐
21. All machine guards are in place	☐	☐	☐	☐
22. Rig ropes not wrapped around body parts	☐	☐	☐	☐
23. Pressurized lines and hoses secured from whipping hazards	☐	☐	☐	☐
24. Drill operation stopped during inclement weather	☐	☐	☐	☐
25. Air monitoring conducted per HSP/FSI for hazardous atmospheres	☐	☐	☐	☐
26. Rig placed in neutral when operator not at controls	☐	☐	☐	☐
DRILL RIG MAINTENANCE (3.2.5)				
27. Defective components repaired immediately	☐	☐	☐	☐
28. Lockout/tagout procedures used prior to maintenance	☐	☐	☐	☐
29. Cathead in clean, sound condition	☐	☐	☐	☐
30. Drill rig ropes in clean, sound condition	☐	☐	☐	☐
31. Fall protection used for fall exposures of 6 feet or greater	☐	☐	☐	☐
32. Rig in neutral and augers stopped rotating before cleaning	☐	☐	☐	☐
33. Good housekeeping maintained on and around rig	☐	☐	☐	☐
DRILLING AT HAZARDOUS WASTE SITES (3.2.6)				
34. Waste disposed of according to HSP	☐	☐	☐	☐
35. Appropriate decontamination procedures being followed, per HSP	☐	☐	☐	☐

Rev.0

SECTION 3

Complete this section for all items checked "No" in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Rev.0

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 7

Applicable Material Safety Data Sheets

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
959 ROUTE 46 EAST
PARSIPPANY, NEW JERSEY 07054-0624

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300
INFORMATION CONTACT:
973-257-1100

SUBSTANCE: TRANS-1,2-DICHLOROETHYLENE

TRADE NAMES/SYNONYMS:
MTG MSDS 196; TRANS-ACETYLENE DICHLORIDE; TRANS-DICHLOROETHYLENE; TRANS-1,2-DICHLOROETHENE; RCRA U079; C2H2CL2; MAT23670; RTECS KV9400000

CHEMICAL FAMILY: halogenated, aliphatic

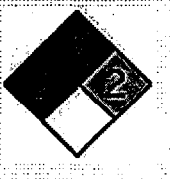
CREATION DATE: Jan 24 1989
REVISION DATE: Dec 16 2002

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: TRANS-1,2-DICHLOROETHYLENE
CAS NUMBER: 156-60-5
PERCENTAGE: 100.0

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=2



EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: liquid
ODOR: pleasant odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression
PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire. May react on contact with air, heat, light or water.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, drowsiness, symptoms of drunkenness
LONG TERM EXPOSURE: no information on significant adverse effects
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: same as effects reported in short term exposure

EYE CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:
SHORT TERM EXPOSURE: symptoms of drunkenness
LONG TERM EXPOSURE: no information on significant adverse effects

SECTION 4 FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. Get immediate medical attention.

SKIN CONTACT: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.

EYE CONTACT: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

INGESTION: If vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.

NOTE TO PHYSICIAN: For ingestion, consider gastric lavage. Consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. Vapor/air mixtures are explosive above flash point. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back.

EXTINGUISHING MEDIA: regular dry chemical, carbon dioxide, water, regular foam

Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Evacuation radius: 800 meters (1/2 mile). Do not attempt to extinguish fire unless flow of material can be stopped first. Flood with fine water spray. Do not scatter spilled material with high-pressure water streams. Cool containers with water spray until well after the fire is out. Apply water from a protected location or from a safe distance. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas. Water may be ineffective.

FLASH POINT: 36 F (2 C) (CC)
LOWER FLAMMABLE LIMIT: 9.7%
UPPER FLAMMABLE LIMIT: 12.8%
AUTOIGNITION: 860 F (460 C)
FLAMMABILITY CLASS (OSHA): IB

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Large spills: Dike for later disposal. Remove sources of ignition. Keep unnecessary people away, isolate hazard area and deny entry. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Grounding and bonding required. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
TRANS-1,2-DICHLOROETHYLENE:
1,2-DICHLOROETHYLENE (ALL ISOMERS):
200 ppm (790 mg/m3) OSHA TWA
200 ppm ACGIH TWA
200 ppm (790 mg/m3) NIOSH recommended TWA 10 hour(s)

VENTILATION: Provide local exhaust ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
1000 ppm
Any supplied-air respirator operated in a continuous-flow mode.
Any powered, air-purifying respirator with organic vapor cartridge(s).
Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s).
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Escape -

Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: liquid
COLOR: colorless
ODOR: pleasant odor
MOLECULAR WEIGHT: 96.94
MOLECULAR FORMULA: C2-H2-CL2
BOILING POINT: 118 F (48 C)
FREEZING POINT: -58 F (-50 C)
VAPOR PRESSURE: 400 mmHg @ 31 C
VAPOR DENSITY (air=1): 3.34
SPECIFIC GRAVITY (water=1): 1.2565
WATER SOLUBILITY: slightly soluble
PH: Not available
VOLATILITY: Not available
ODOR THRESHOLD: Not available
EVAPORATION RATE: Not available
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: ethanol, ether

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: May decompose on contact with air, light, moisture, heat or storage and use above room temperature. Releases toxic, corrosive, flammable or explosive gases.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat. Keep out of water supplies and sewers.

INCOMPATIBILITIES: bases, metals, combustible materials, oxidizing materials, acids

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: phosgene, halogenated compounds, oxides of carbon

POLYMERIZATION: May polymerize. Avoid contact with incompatible materials.

SECTION 11 TOXICOLOGICAL INFORMATION

TRANS-1,2-DICHLOROETHYLENE:
IRRITATION DATA:
500 mg/24 hour(s) skin-rabbit moderate; 10 mg eyes-rabbit moderate

TOXICITY DATA:
24100 ppm inhalation-rat LC50; >5 gm/kg skin-rabbit LD50; 1235 mg/kg oral-rat LD50
LOCAL EFFECTS:
Irritant: inhalation, skin, eye
ACUTE TOXICITY LEVEL:
Moderately Toxic: ingestion
Slightly Toxic: inhalation
TARGET ORGANS: central nervous system
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: respiratory disorders
MUTAGENIC DATA: Available.
REPRODUCTIVE EFFECTS DATA: Available.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
INVERTEBRATE TOXICITY: <110000 ug/L 48 hour(s) (Mortality) Water flea (Daphnia magna)

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): D001. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: Trichlorobenzenes, liquid
ID NUMBER: UN2321
HAZARD CLASS OR DIVISION: 6.1
PACKING GROUP: III
LABELING REQUIREMENTS: 6.1

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: Trichlorobenzenes, liquid
ID NUMBER: UN2321
CLASSIFICATION: 6.1
PACKING GROUP: III

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4): Not regulated.

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.40): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):
ACUTE: Yes
CHRONIC: No
FIRE: Yes
REACTIVE: Yes
SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65):
1,2-DICHLOROETHYLENE (ALL ISOMERS)

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65: Not regulated.

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: Not determined.

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDSL): Not determined.

SECTION 16 OTHER INFORMATION

MSDS SUMMARY OF CHANGES
SECTION 15 REGULATORY INFORMATION

MATHESON TRI-GAS, INC. MAKES NO EXPRESS OR IMPLIED WARRANTIES, GUARANTEES OR REPRESENTATIONS REGARDING THE PRODUCT OR THE INFORMATION HEREIN, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR USE. MATHESON TRI-GAS, INC. SHALL NOT BE LIABLE FOR ANY PERSONAL INJURY, PROPERTY OR OTHER DAMAGES OF ANY NATURE, WHETHER COMPENSATORY, CONSEQUENTIAL, EXEMPLARY, OR OTHERWISE, RESULTING FROM ANY PUBLICATION, USE OR RELIANCE UPON THE INFORMATION HEREIN.

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
959 ROUTE 46 EAST
PARSIPPANY, NEW JERSEY 07054-0624

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300
INFORMATION CONTACT:
973-257-1100

SUBSTANCE: TETRACHLOROETHYLENE

TRADE NAMES/SYNONYMS:
MTG MSDS 238; PERCHLOROETHYLENE; 1,1,2,2-TETRACHLOROETHYLENE; ETHYLENE TETRACHLORIDE; PERC; TETRACHLORETHYLENE; PERCHLORETHYLENE; TETRACHLOROETHENE; PCE; RCRA U210; UN 1897; C2Cl4; MAT22900; RTECS KX3850000

CHEMICAL FAMILY: halogenated, aliphatic

CREATION DATE: Jan 24 1989
REVISION DATE: Dec 16 2002

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: TETRACHLOROETHYLENE
CAS NUMBER: 127-18-4
PERCENTAGE: 100.0

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=0

EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: volatile liquid
ODOR: faint odor, sweet odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression, cancer hazard (in humans)

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, chest pain, difficulty breathing, irregular heartbeat, headache, drowsiness, dizziness, disorientation, mood swings, loss of coordination, blurred vision, lung congestion, kidney damage, liver damage
LONG TERM EXPOSURE: irritation, nausea, stomach pain, loss of appetite, headache, drowsiness, dizziness, disorientation, sleep disturbances, pain in extremities, loss of coordination, blurred vision, hormonal disorders, internal bleeding, heart damage, liver damage, birth defects, brain damage, tumors,

cancer
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation (possibly severe)
LONG TERM EXPOSURE: irritation
EYE CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: irritation
INGESTION:
SHORT TERM EXPOSURE: same as effects reported in short term inhalation
LONG TERM EXPOSURE: same as effects reported in long term inhalation

SECTION 4 FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

SKIN CONTACT: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.

EYE CONTACT: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

INGESTION: If vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.

NOTE TO PHYSICIAN: For inhalation, consider oxygen. For ingestion, consider gastric lavage. Consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Negligible fire hazard.

EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical

Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For tank, rail car or tank truck, evacuation radius: 800 meters (1/2 mile).

FLASH POINT: No data available.

SECTION 6 ACCIDENTAL RELEASE MEASURES

SOIL RELEASE:
Dig holding area such as lagoon, pond or pit for containment. Dike for later disposal. Absorb with sand or other non-combustible material.

WATER RELEASE:
Absorb with activated carbon. Remove trapped material with suction hoses. Subject to California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Keep out of water supplies and sewers.

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Small liquid spills: Absorb with sand or other non-combustible material. Large spills: Dike for later disposal. Remove sources of ignition. Keep unnecessary people away, isolate hazard area and deny entry. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Store in a cool, dry place. Store in a well-ventilated area. Avoid heat, flames, sparks and other sources of ignition. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
TETRACHLOROETHYLENE:
TETRACHLOROETHYLENE (PERCHLOROETHYLENE):
100 ppm OSHA TWA
200 ppm OSHA ceiling
300 ppm OSHA peak 5 minute(s)/3 hour(s)
25 ppm (170 mg/m3) OSHA TWA (vacated by 58 FR 35338, June 30, 1993)
25 ppm ACGIH TWA
100 ppm ACGIH STEL

VENTILATION: Provide local exhaust or process enclosure ventilation system. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
At any detectable concentration -
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.

Escape -
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: liquid
APPEARANCE: clear
COLOR: colorless
PHYSICAL FORM: volatile liquid
ODOR: faint odor, sweet odor
MOLECULAR WEIGHT: 165.83
MOLECULAR FORMULA: Cl2-C-C-Cl2
BOILING POINT: 250 F (121 C)
FREEZING POINT: -2 F (-19 C)
VAPOR PRESSURE: 14 mmHg @ 20 C
VAPOR DENSITY (air=1): 5.83
SPECIFIC GRAVITY (water=1): 1.6227
WATER SOLUBILITY: 0.015%
PH: Not available
VOLATILITY: Not available
ODOR THRESHOLD: 50 ppm
EVAPORATION RATE: 2.8 (butyl acetate=1)
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, benzene, chloroform, oils

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.

INCOMPATIBILITIES: acids, metals, bases, oxidizing materials, combustible materials

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: phosgene, halogenated compounds, oxides of carbon

POLYMERIZATION: Will not polymerize.

SECTION 11 TOXICOLOGICAL INFORMATION

TETRACHLOROETHYLENE:

IRRITATION DATA:
810 mg/24 hour(s) skin-rabbit severe; 500 mg/24 hour(s) skin-rabbit mild; 162 mg eyes-rabbit mild; 500 mg/24 hour(s) eyes-rabbit mild
TOXICITY DATA:
34200 mg/m3/8 hour(s) inhalation-rat LC50; >10000 mg/kg skin-rabbit LD50 (Dow); 2629 mg/kg oral-rat LD50
CARCINOGEN STATUS: NTP: Anticipated Human Carcinogen; IARC: Human Limited Evidence, Animal Sufficient Evidence, Group 2A; ACGIH: A3 -Animal Carcinogen; EC: Category 2
LOCAL EFFECTS:
Irritant: inhalation, skin, eye
ACUTE TOXICITY LEVEL:
Moderately Toxic: ingestion
Slightly Toxic: inhalation
TARGET ORGANS: central nervous system
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: eye disorders, heart or cardiovascular disorders, kidney disorders, liver disorders, nervous system disorders, skin disorders and allergies
TUMORIGENIC DATA: Available.
MUTAGENIC DATA: Available.
REPRODUCTIVE EFFECTS DATA: Available.
ADDITIONAL DATA: May be excreted in breast milk. Alcohol may enhance the toxic effects. Stimulants such as epinephrine may induce ventricular fibrillation.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
FISH TOXICITY: 8430 ug/L 96 hour(s) LC50 (Mortality) Flagfish (Jordanella floridae)

INVERTEBRATE TOXICITY: 7500 ug/L 48 hour(s) EC50 (Immobilization) Water flea (Daphnia magna)

ALGAL TOXICITY: 509000 ug/L 96 hour(s) EC50 (Photosynthesis) Diatom (Skeletonema costatum)

FATE AND TRANSPORT:
BIOCONCENTRATION: 49 ug/L 1-21 hour(s) BCF (Residue) Bluegill (Lepomis macrochirus) 3.43 ug/L

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): U210. Hazardous Waste Number(s): D039. Dispose of in accordance with U.S. EPA 40 CFR 262 for concentrations at or above the Regulatory level. Regulatory level- 0.7 mg/L. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: Tetrachloroethylene
ID NUMBER: UN1897
HAZARD CLASS OR DIVISION: 6.1
PACKING GROUP: III

LABELING REQUIREMENTS: 6.1
MARINE POLLUTANT: TETRACHLOROETHYLENE

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: Tetrachloroethylene
ID NUMBER: UN1897
CLASSIFICATION: 6.1
PACKING GROUP: III

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4):
TETRACHLOROETHYLENE (PERCHLOROETHYLENE): 100 LBS RQ

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.40): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):
ACUTE: Yes
CHRONIC: Yes
FIRE: No
REACTIVE: No
SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65):
TETRACHLOROETHYLENE (PERCHLOROETHYLENE)

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65:
Known to the state of California to cause the following:
TETRACHLOROETHYLENE (PERCHLOROETHYLENE)
Cancer (Apr 01, 1988)

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: D2

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDSL): Not determined.

SECTION 16 OTHER INFORMATION

MSDS SUMMARY OF CHANGES
SECTION 15 REGULATORY INFORMATION

MATHESON TRI-GAS, INC. MAKES NO EXPRESS OR IMPLIED WARRANTIES, GUARANTEES OR REPRESENTATIONS REGARDING THE PRODUCT OR THE INFORMATION HEREIN, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR USE. MATHESON TRI-GAS, INC. SHALL NOT BE LIABLE FOR ANY PERSONAL INJURY, PROPERTY OR OTHER DAMAGES OF ANY NATURE, WHETHER COMPENSATORY, CONSEQUENTIAL, EXEMPLARY, OR OTHERWISE, RESULTING FROM ANY PUBLICATION, USE OR RELIANCE UPON THE INFORMATION HEREIN.

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
959 ROUTE 46 EAST
PARSIPPANY, NEW JERSEY 07054-0624

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300
INFORMATION CONTACT:
973-257-1100

SUBSTANCE: 1,1,2,2-TETRACHLOROETHANE

TRADE NAMES/SYNONYMS:
MTG MSDS 160; S-TETRACHLOROETHANE; ACETYLENE TETRACHLORIDE; SYM-TETRACHLOROETHANE; 1,1-DICHLORO-2,2-DICHLOROETHANE; ETHANE, 1,1,2,2-TETRACHLORO-; TETRACHLOROETHANE; SYMMETRICAL TETRACHLOROETHANE; CELLON; BONOFORM; STCC 4940354; RCRA U209; UN 1702; $C_2H_2Cl_4$; MAT26400; RTECS KI8575000

CHEMICAL FAMILY: halogenated, aliphatic

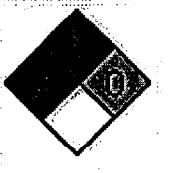
CREATION DATE: Jan 24 1989
REVISION DATE: Dec 16 2002

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: 1,1,2,2-TETRACHLOROETHANE
CAS NUMBER: 79-34-5
PERCENTAGE: 100.0

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=1 REACTIVITY=0



EMERGENCY OVERVIEW:
COLOR: colorless to yellow
PHYSICAL FORM: liquid
ODOR: sweet odor
MAJOR HEALTH HAZARDS: harmful if inhaled, respiratory tract irritation, skin irritation, eye irritation, central nervous system depression

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, rash, nausea, stomach pain, difficulty breathing, headache, drowsiness, symptoms of drunkenness, disorientation, tingling sensation, lung congestion, kidney damage, liver damage, convulsions, coma
LONG TERM EXPOSURE: no information on significant adverse effects
SKIN CONTACT:

SHORT TERM EXPOSURE: same as effects reported in short term inhalation, irritation, rash
LONG TERM EXPOSURE: same as effects reported in short term exposure
EYE CONTACT:
SHORT TERM EXPOSURE: irritation, tearing, eye damage
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:
SHORT TERM EXPOSURE: same as effects reported in short term inhalation, symptoms of drunkenness, liver damage, coma
LONG TERM EXPOSURE: no information on significant adverse effects

SECTION 4 FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

SKIN CONTACT: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.

EYE CONTACT: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

INGESTION: If vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.

NOTE TO PHYSICIAN: For inhalation, consider oxygen. For ingestion, consider gastric lavage. Consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Slight fire hazard.

EXTINGUISHING MEDIA: regular dry chemical, carbon dioxide, water, regular foam

Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Move container from fire area if it can be done without risk. Do not scatter spilled material with high-pressure water streams. Dike for later disposal. Use extinguishing agents appropriate for surrounding fire. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas.

FLASH POINT: No data available.

SECTION 6 ACCIDENTAL RELEASE MEASURES

WATER RELEASE:
Subject to California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Keep out of

water supplies and sewers.

OCCUPATIONAL RELEASE:
Stop leak if possible without personal risk. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Keep unnecessary people away, isolate hazard area and deny entry. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Keep separated from incompatible substances. Store in a cool, dry place. Keep in the dark.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
1,1,2,2-TETRACHLOROETHANE:
5 ppm (35 mg/m3) OSHA TWA (skin)
1 ppm (7 mg/m3) OSHA TWA (skin) (vacated by 58 FR 35338, June 30, 1993)
1 ppm ACGIH TWA (skin)
1 ppm (7 mg/m3) NIOSH recommended TWA 10 hour(s) (skin)

VENTILATION: Provide local exhaust or process enclosure ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
At any detectable concentration -
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Escape -
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: liquid
COLOR: colorless to yellow
ODOR: sweet odor
MOLECULAR WEIGHT: 167.85
MOLECULAR FORMULA: C-H-Cl2-C-H-Cl2
BOILING POINT: 295 F (146 C)
FREEZING POINT: -33 F (-36 C)
VAPOR PRESSURE: 8 mmHg @ 20 C
VAPOR DENSITY (air=1): 5.79
SPECIFIC GRAVITY (water=1): 1.5953
WATER SOLUBILITY: 0.28% @ 25 C
PH: Not available
VOLATILITY: 100%
ODOR THRESHOLD: <3 ppm
EVAPORATION RATE: 0.65 (butyl acetate=1)
VISCOSITY: 1.7 cP @ 20 C
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: methanol, ethanol, benzene, acetone, ether, chloroform, carbon tetrachloride, petroleum ether, dimethylformamide, carbon disulfide, oils

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Avoid contact with incompatible materials.

INCOMPATIBILITIES: bases, metals, oxidizing materials, sulfides, combustible materials

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: acid halides, phosgene, oxides of carbon, halogenated compounds

POLYMERIZATION: Will not polymerize.

SECTION 11 TOXICOLOGICAL INFORMATION

1,1,2,2-TETRACHLOROETHANE:
TOXICITY DATA:
4500 mg/m3/2 hour(s) inhalation-mouse LC50; 200 mg/kg oral-rat LD50
CARCINOGEN STATUS: IARC: Human Inadequate Evidence, Animal Limited Evidence, Group 3; ACGIH: A3 -Animal Carcinogen
LOCAL EFFECTS:
Irritant: inhalation, skin, eye
ACUTE TOXICITY LEVEL:

Toxic: inhalation, ingestion
TARGET ORGANS: central nervous system, liver
TUMORIGENIC DATA: Available.
MUTAGENIC DATA: Available.
ADDITIONAL DATA: Alcohol may enhance the toxic effects.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
FISH TOXICITY: 12000 ug/L 96 hour(s) LC50 (Mortality) Sheepshead minnow (Cyprinodon variegatus)

INVERTEBRATE TOXICITY: 23000 ug/L 48 hour(s) EC50 (Immobilization) Water flea (Daphnia magna)

ALGAL TOXICITY: 6440 ug/L 96 hour(s) EC50 (Photosynthesis) Diatom (Skeletonema costatum)

FATE AND TRANSPORT:
BIOCONCENTRATION: 8 ug/L 1-14 hour(s) BCF (Residue) Bluegill (Lepomis macrochirus) 9.62 ug/L

ENVIRONMENTAL SUMMARY: Moderately toxic to aquatic life.

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): U209. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: Tetrabromoethane
ID NUMBER: UN2504
HAZARD CLASS OR DIVISION: 6.1
PACKING GROUP: III
LABELING REQUIREMENTS: 6.1

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: Tetrabromoethane
ID NUMBER: UN2504
CLASSIFICATION: 6.1
PACKING GROUP: III

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4):
1,1,2,2-TETRACHLOROETHANE: 100 LBS RQ

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.40): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):
ACUTE: Yes
CHRONIC: Yes
FIRE: No
REACTIVE: No
SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65):
1,1,2,2-TETRACHLOROETHANE

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65:
Known to the state of California to cause the following:
1,1,2,2-TETRACHLOROETHANE
Cancer (Jul 01, 1990)

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: D2

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION:
1,1,2,2-TETRACHLOROETHANE
CAS NUMBER: 79-34-5
SECTION 4

CANADA INVENTORY (DSL/NDSL): Not determined.

SECTION 16 OTHER INFORMATION

MSDS SUMMARY OF CHANGES
SECTION 15 REGULATORY INFORMATION

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OTHERWISE, RESULTING FROM ANY PUBLICATION, USE OR RELIANCE UPON THE INFORMATION HEREIN.

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
959 ROUTE 46 EAST
PARSIPPANY, NEW JERSEY 07054-0624

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300
INFORMATION CONTACT:
973-257-1100

SUBSTANCE: VINYL CHLORIDE

TRADE NAMES/SYNONYMS:
MTG MSDS 97; CHLOROETHYLENE; CHLOROETHENE; CHLORETHENE; TROVIDUR; ETHYLENE MONOCHLORIDE; MONOCHLOROETHYLENE; EXON 470; MONOCHLORO ETHENE; VINYL CHLORIDE MONOMER; VINYL CHLORIDE, INHIBITED; STCC 4905792; RCRA U043; UN 1086; C2H3CL; MAT24940; RTECS KU9625000

CHEMICAL FAMILY: halogenated, aliphatic

CREATION DATE: Jan 24 1989
REVISION DATE: Dec 16 2002

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: VINYL CHLORIDE
CAS NUMBER: 75-01-4
PERCENTAGE: >99.9

COMPONENT: PHENOL
CAS NUMBER: 108-95-2
PERCENTAGE: <0.1

COMPONENT: INHIBITORS
CAS NUMBER: Not assigned.
PERCENTAGE: <0.1

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=4 REACTIVITY=1

EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: gas
ODOR: faint odor, sweet odor
MAJOR HEALTH HAZARDS: harmful if swallowed, skin irritation, eye irritation, central nervous system depression, cancer hazard (in humans)

PHYSICAL HAZARDS: Flammable gas. May cause flash fire. May polymerize. Containers may rupture or explode.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, difficulty breathing, irregular heartbeat, headache, drowsiness, symptoms of drunkenness, disorientation, joint pain, hearing loss, lung congestion
LONG TERM EXPOSURE: impotence, bluish skin color, blood disorders, liver damage, cancer
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation, blisters
LONG TERM EXPOSURE: same as effects reported in short term exposure
EYE CONTACT:
SHORT TERM EXPOSURE: irritation, eye damage
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:
SHORT TERM EXPOSURE: frostbite
LONG TERM EXPOSURE: cancer

SECTION 4 FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

SKIN CONTACT: If frostbite or freezing occur, immediately flush with plenty of lukewarm water (105-115 F; 41-46 C). DO NOT USE HOT WATER. If warm water is not available, gently wrap affected parts in blankets. Get immediate medical attention.

EYE CONTACT: Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains. Get medical attention immediately.

INGESTION: If a large amount is swallowed, get medical attention.

NOTE TO PHYSICIAN: For inhalation, consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. Severe explosion hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive. Electrostatic discharges may be generated by flow or agitation resulting in ignition or explosion.

EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical

Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Move container from fire area if it can be done without risk. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device

or any discoloration of tanks due to fire. For tank, rail car or tank truck: Stop leak if possible without personal risk. Let burn unless leak can be stopped immediately. For smaller tanks or cylinders, extinguish and isolate from other flammables. Evacuation radius: 800 meters (1/2 mile). Stop flow of gas.

FLASH POINT: -108 F (-78 C)
LOWER FLAMMABLE LIMIT: 3.6%
UPPER FLAMMABLE LIMIT: 33%
AUTOIGNITION: 882 F (472 C)

SECTION 6 ACCIDENTAL RELEASE MEASURES

WATER RELEASE:
Subject to California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Keep out of water supplies and sewers.

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Keep unnecessary people away, isolate hazard area and deny entry. Remove sources of ignition. Ventilate closed spaces before entering. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.101. Protect from physical damage. Store outside or in a detached building. Inside storage: Store in a cool, dry place. Store in a well-ventilated area. Avoid heat, flames, sparks and other sources of ignition. Keep separated from incompatible substances. Grounding and bonding required. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
VINYL CHLORIDE:
1.0 ppm OSHA TWA
5 ppm OSHA ceiling 15 minute(s)
0.5 ppm OSHA action level
1 ppm ACGIH TWA

VENTILATION: Provide local exhaust or process enclosure ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: For the gas: Wear appropriate chemical resistant gloves. For the liquid: Wear insulated gloves.
OSHA REGULATED SUBSTANCES: U.S. OSHA 29 CFR 1910.1017.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.

10 p/m

Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.

Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode.

Any chemical cartridge respirator with cartridge(s) providing protection against this substance.

25 p/m

Any powered, air-purifying respirator with a tight-fitting facepiece and cartridge(s) providing protection against this substance.

Any air-purifying respirator with a full facepiece, a canister providing protection against this substance, and a high-efficiency particulate filter.

100 p/m

Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode.

1000 p/m

Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.

Any supplied-air respirator operated in a continuous-flow mode.

Any supplied-air respirator with a full facepiece.

Any supplied-air respirator operated in a continuous-flow mode.

3600 p/m

Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.

For Unknown Concentrations or Immediately Dangerous to Life or Health -

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: gas
COLOR: colorless
ODOR: faint odor, sweet odor
MOLECULAR WEIGHT: 62.50
MOLECULAR FORMULA: C-H2-C-H-CL
BOILING POINT: 9 F (-13 C)
FREEZING POINT: -245 F (-154 C)
VAPOR PRESSURE: 2515.6 mmHg @ 21.1 C
VAPOR DENSITY (air=1): 2.2
SPECIFIC GRAVITY (water=1): 0.9106
WATER SOLUBILITY: 0.25%

PH: Not applicable
VOLATILITY: Not applicable
ODOR THRESHOLD: 260 ppm
EVAPORATION RATE: Not applicable
VISCOSITY: 0.01072 cP @ 20 C
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, carbon tetrachloride, benzene

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: May polymerize. Avoid contact with light or storage and use above room temperature.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.

INCOMPATIBILITIES: metal carbide, metals, oxidizing materials, peroxides

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: phosgene, halogenated compounds, oxides of carbon

POLYMERIZATION: May polymerize. Avoid contact with heat, light, air, water or incompatible materials. Closed containers may rupture violently.

SECTION 11 TOXICOLOGICAL INFORMATION

VINYL CHLORIDE:
TOXICITY DATA:
18 pph/15 minute(s) inhalation-rat LC50; 500 mg/kg oral-rat LD50
CARCINOGEN STATUS: OSHA: Carcinogen; NTP: Known Human Carcinogen; IARC: Human Sufficient Evidence, Animal Sufficient Evidence, Group 1; ACGIH: A1 -Confirmed Human Carcinogen; EC: Category 1
LOCAL EFFECTS:
Irritant: skin, eye
ACUTE TOXICITY LEVEL:
Toxic: ingestion
Relatively Non-toxic: inhalation
TARGET ORGANS: central nervous system
TUMORIGENIC DATA: Available.
MUTAGENIC DATA: Available.
REPRODUCTIVE EFFECTS DATA: Available.
ADDITIONAL DATA: Stimulants such as epinephrine may induce ventricular fibrillation.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
FISH TOXICITY: 388000 ug/L 10 month(s) LETH (Mortality) Northern pike (Esox lucius)

INVERTEBRATE TOXICITY: 41.74 ug/L 72 day(s) (Residue) Mosquito (Culex pipiens quinquefasciata)

ALGAL TOXICITY: 41.74 ug/L 72 day(s) (Residue) Green algae (Oedogonium cardiacum)

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): U043. Hazardous Waste Number(s): D043. Dispose of in accordance with U.S. EPA 40 CFR 262 for concentrations at or above the Regulatory level. Regulatory level- 0.2 mg/L. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: Vinyl chloride, stabilized
ID NUMBER: UN1086
HAZARD CLASS OR DIVISION: 2.1
LABELING REQUIREMENTS: 2.1

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: Vinyl chloride, stabilized
ID NUMBER: UN1086
CLASSIFICATION: 2.1

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4):
Vinyl chloride: 1 LBS RQ
PHENOL: 1000 LBS RQ

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.40): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):
ACUTE: Yes
CHRONIC: Yes
FIRE: Yes
REACTIVE: Yes
SUDDEN RELEASE: Yes

SARA TITLE III SECTION 313 (40 CFR 372.65):
Vinyl chloride

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65:
Known to the state of California to cause the following:
Vinyl chloride
Cancer (Feb 27, 1987)

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: ABD2

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDSL): Not determined.

SECTION 16 OTHER INFORMATION

MSDS SUMMARY OF CHANGES
SECTION 15 REGULATORY INFORMATION

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MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
959 ROUTE 46 EAST
PARSIPPANY, NEW JERSEY 07054-0624

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300
INFORMATION CONTACT:
973-257-1100

SUBSTANCE: TRICHLOROETHYLENE

TRADE NAMES/SYNONYMS:
MTG MSDS 199; ACETYLENE TRICHLORIDE; ETHYLENE TRICHLORIDE; 1-CHLORO-2,2-DICHLOROETHYLENE; 1,1-DICHLORO-2-CHLOROETHYLENE; TCE; ETHINYL TRICHLORIDE; TRICHLOROETHENE; 1,1,2-TRICHLOROETHYLENE; 1,1,2-TRICHLOROETHENE; UN 1710; RCRA U228; C2HCl3; MAT23850; RTECS KX4550000

CHEMICAL FAMILY: halogenated, alkenes

CREATION DATE: Jan 24 1989
REVISION DATE: Dec 16 2002

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: TRICHLOROETHYLENE
CAS NUMBER: 79-01-6
PERCENTAGE: >99

COMPONENT: INHIBITORS
CAS NUMBER: Not assigned.
PERCENTAGE: <0.1

COMPONENT: AMINES
CAS NUMBER: Not assigned.
PERCENTAGE: <0.1

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=1 REACTIVITY=0

EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: liquid
ODOR: sweet odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression, allergic reactions, cancer hazard (in humans)

PHYSICAL HAZARDS: May polymerize. Containers may rupture or explode. May decompose on contact with air, light, moisture, heat or storage and use above room temperature. Releases toxic, corrosive, flammable or explosive gases.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, changes in blood pressure, nausea, vomiting, stomach pain, difficulty breathing, irregular heartbeat, headache, drowsiness, dizziness, disorientation, mood swings, tremors, loss of coordination, visual disturbances, bluish skin color, lung congestion, kidney damage, liver damage, unconsciousness, coma
LONG TERM EXPOSURE: same as effects reported in short term exposure, loss of appetite, weight loss, blood disorders, brain damage, cancer
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation, allergic reactions
LONG TERM EXPOSURE: irritation, allergic reactions, nausea, loss of appetite, weight loss, difficulty breathing, headache, drowsiness, dizziness, joint pain, loss of coordination, visual disturbances, paralysis
EYE CONTACT:
SHORT TERM EXPOSURE: irritation (possibly severe), blurred vision
LONG TERM EXPOSURE: irritation (possibly severe), eye damage
INGESTION:
SHORT TERM EXPOSURE: same as effects reported in short term inhalation
LONG TERM EXPOSURE: same as effects reported in long term inhalation

SECTION 4 FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. Get immediate medical attention.

SKIN CONTACT: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.

EYE CONTACT: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

INGESTION: If vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.

NOTE TO PHYSICIAN: For ingestion, consider gastric lavage. Consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Slight fire hazard.

EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical

Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Cool containers with water spray until well after the fire is out. Stay away from the ends

of tanks. For tank, rail car or tank truck, evacuation radius: 800 meters (1/2 mile).

FLASH POINT: No data available.
LOWER FLAMMABLE LIMIT: 7.8% @ 100 C
UPPER FLAMMABLE LIMIT: 52% @ 100 C
AUTOIGNITION: 770 F (410 C)

SECTION 6 ACCIDENTAL RELEASE MEASURES

AIR RELEASE:
Reduce vapors with water spray. Collect runoff for disposal as potential hazardous waste.

SOIL RELEASE:
Dig holding area such as lagoon, pond or pit for containment. Dike for later disposal. Absorb with sand or other non-combustible material.

WATER RELEASE:
Absorb with activated carbon. Remove trapped material with suction hoses. Collect spilled material using mechanical equipment. Subject to California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Keep out of water supplies and sewers.

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Small liquid spills: Absorb with sand or other non-combustible material. Large spills: Dike for later disposal. Remove sources of ignition. Keep unnecessary people away, isolate hazard area and deny entry. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Store in a cool, dry place. Store in a well-ventilated area. Avoid heat, flames, sparks and other sources of ignition. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
TRICHLOROETHYLENE:
100 ppm OSHA TWA
200 ppm OSHA ceiling
300 ppm OSHA peak 5 minute(s)/2 hour(s)
50 ppm (269 mg/m3) OSHA TWA (vacated by 58 FR 35338, June 30, 1993)
200 ppm (1070 mg/m3) OSHA STEL (vacated by 58 FR 35338, June 30, 1993)
50 ppm ACGIH TWA
100 ppm ACGIH STEL

VENTILATION: Provide local exhaust ventilation system. Ensure compliance with applicable exposure

limits.

EYE PROTECTION: Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
At any detectable concentration -
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Escape -
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: liquid
COLOR: colorless
ODOR: sweet odor
MOLECULAR WEIGHT: 131.39
MOLECULAR FORMULA: Cl-C-H-C-Cl2
BOILING POINT: 189 F (87 C)
FREEZING POINT: -99 F (-73 C)
VAPOR PRESSURE: 58 mmHg @ 20 C
VAPOR DENSITY (air=1): 4.53
SPECIFIC GRAVITY (water=1): 1.4642
WATER SOLUBILITY: 0.1%
PH: Not available
VOLATILITY: Not available
ODOR THRESHOLD: 21 ppm
EVAPORATION RATE: 0.69 (carbon tetrachloride=1)
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, acetone, chloroform, benzene, vegetable oils

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: May decompose on contact with air, light, moisture, heat or storage and use above room temperature. Releases toxic, corrosive, flammable or explosive gases.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.

INCOMPATIBILITIES: bases, metals, combustible materials, oxidizing materials

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: phosgene, halogenated compounds, oxides of carbon

POLYMERIZATION: May polymerize. Avoid contact with heat or light and monitor inhibitor content.

SECTION 11 TOXICOLOGICAL INFORMATION

TRICHLOROETHYLENE:
IRRITATION DATA:
2 mg/24 hour(s) skin-rabbit severe; 20 mg/24 hour(s) eyes-rabbit moderate
TOXICITY DATA:
8450 ppm/4 hour(s) inhalation-mouse LC50; >20 gm/kg skin-rabbit LD50; 4920 mg/kg oral-rat LD50
CARCINOGEN STATUS: NTP: Anticipated Human Carcinogen; IARC: Human Limited Evidence, Animal Sufficient Evidence, Group 2A; ACGIH: A5 -Not Suspected as a Human Carcinogen
LOCAL EFFECTS:
Irritant: inhalation, skin, eye
ACUTE TOXICITY LEVEL:
Moderately Toxic: ingestion
Slightly Toxic: inhalation
TARGET ORGANS: immune system (sensitizer), central nervous system
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: heart problems
TUMORIGENIC DATA: Available.
MUTAGENIC DATA: Available.
REPRODUCTIVE EFFECTS DATA: Available.
ADDITIONAL DATA: May cross the placenta. Stimulants such as epinephrine may induce ventricular fibrillation.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
FISH TOXICITY: 3100 ug/L 96 hour(s) LC50 (Mortality) Flagfish (Jordanella floridae)

INVERTEBRATE TOXICITY: 1700 ug/L 7 hour(s) EC50 (Regeneration) Flatworm (Dugesia japonica)

OTHER TOXICITY: 45000 ug/L 48 week(s) LC50 (Mortality) Clawed toad (Xenopus laevis)

FATE AND TRANSPORT:
BIOCONCENTRATION: 17 ug/L 1-14 hour(s) BCF (Residue) Bluegill (Lepomis macrochirus) 8.23 ug/L

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): U228. Hazardous

Waste Number(s): D040. Dispose of in accordance with U.S. EPA 40 CFR 262 for concentrations at or above the Regulatory level. Regulatory level- 0.5 mg/L. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: Trichloroethylene
ID NUMBER: UN1710
HAZARD CLASS OR DIVISION: 6.1
PACKING GROUP: III
LABELING REQUIREMENTS: 6.1

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: Trichloroethylene
ID NUMBER: UN1710
CLASSIFICATION: 6.1
PACKING GROUP: III

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4):
TRICHLOROETHYLENE: 100 LBS RQ

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.40): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):
ACUTE: Yes
CHRONIC: Yes
FIRE: No
REACTIVE: No
SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65):
TRICHLOROETHYLENE

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65:
Known to the state of California to cause the following:
TRICHLOROETHYLENE
Cancer (Apr 01, 1988)

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: D2

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDSL): Not determined.

SECTION 16 OTHER INFORMATION

MSDS SUMMARY OF CHANGES
SECTION 15 REGULATORY INFORMATION

MATHESON TRI-GAS, INC. MAKES NO EXPRESS OR IMPLIED WARRANTIES, GUARANTEES OR REPRESENTATIONS REGARDING THE PRODUCT OR THE INFORMATION HEREIN, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR USE. MATHESON TRI-GAS, INC. SHALL NOT BE LIABLE FOR ANY PERSONAL INJURY, PROPERTY OR OTHER DAMAGES OF ANY NATURE, WHETHER COMPENSATORY, CONSEQUENTIAL, EXEMPLARY, OR OTHERWISE, RESULTING FROM ANY PUBLICATION, USE OR RELIANCE UPON THE INFORMATION HEREIN.

MATERIAL SAFETY DATA SHEET

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
959 ROUTE 46 EAST
PARSIPPANY, NEW JERSEY 07054-0624

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300
INFORMATION CONTACT:
973-257-1100

SUBSTANCE: CIS-1,2-DICHLOROETHYLENE

TRADE NAMES/SYNONYMS:
CIS-ACETYLENE DICHLORIDE; 1,2-DICHLOROETHYLENE; C2H2CL2; MAT05125; RTECS KV9420000

CHEMICAL FAMILY: halogenated, aliphatic

CREATION DATE: Jan 24 1989
REVISION DATE: Dec 16 2002

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: CIS-1,2-DICHLOROETHYLENE
CAS NUMBER: 156-59-2
PERCENTAGE: 100.0

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=2

EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: liquid
ODOR: pleasant odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression
PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire. May react on contact with air, heat, light or water.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, drowsiness, symptoms of drunkenness
LONG TERM EXPOSURE: no information on significant adverse effects
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: same as effects reported in short term exposure

EYE CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:
SHORT TERM EXPOSURE: symptoms of drunkenness
LONG TERM EXPOSURE: no information on significant adverse effects

SECTION 4 FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. Get immediate medical attention.

SKIN CONTACT: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.

EYE CONTACT: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

INGESTION: If vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.

NOTE TO PHYSICIAN: For ingestion, consider gastric lavage. Consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. Moderate explosion hazard. Vapor/air mixtures are explosive above flash point. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back.

EXTINGUISHING MEDIA: regular dry chemical, carbon dioxide, water, regular foam

Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Evacuation radius: 800 meters (1/2 mile). Do not attempt to extinguish fire unless flow of material can be stopped first. Flood with fine water spray. Do not scatter spilled material with high-pressure water streams. Cool containers with water spray until well after the fire is out. Apply water from a protected location or from a safe distance. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas. Water may be ineffective.

FLASH POINT: 39 F (4 C) (CC)
LOWER FLAMMABLE LIMIT: 9.7%
UPPER FLAMMABLE LIMIT: 12.8%
FLAMMABILITY CLASS (OSHA): IB

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Large spills: Dike for later disposal. Remove sources of ignition. Keep unnecessary people away, isolate hazard area and deny entry.

SECTION 7 HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Grounding and bonding required. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
CIS-1,2-DICHLOROETHYLENE:
1,2-DICHLOROETHYLENE (ALL ISOMERS):
200 ppm (790 mg/m3) OSHA TWA
200 ppm ACGIH TWA
200 ppm (790 mg/m3) NIOSH recommended TWA 10 hour(s)

VENTILATION: Provide local exhaust ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
1000 ppm
Any supplied-air respirator operated in a continuous-flow mode.
Any powered, air-purifying respirator with organic vapor cartridge(s).
Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s).
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Escape -
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -

Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: liquid
COLOR: colorless
ODOR: pleasant odor
MOLECULAR WEIGHT: 96.94
MOLECULAR FORMULA: C2-H2-CL2
BOILING POINT: 140 F (60 C)
FREEZING POINT: -114 F (-81 C)
VAPOR PRESSURE: 400 mmHg @ 41 C
VAPOR DENSITY (air=1): 3.34
SPECIFIC GRAVITY (water=1): 1.2837
WATER SOLUBILITY: insoluble
PH: Not available
VOLATILITY: Not available
ODOR THRESHOLD: Not available
EVAPORATION RATE: Not available
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: acetone, benzene, ether, alcohol

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: May decompose on contact with air, light, moisture, heat or storage and use above room temperature. Releases toxic, corrosive, flammable or explosive gases.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat. Keep out of water supplies and sewers.

INCOMPATIBILITIES: bases, metals, combustible materials, oxidizing materials, acids

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: phosgene, halogenated compounds, oxides of carbon

POLYMERIZATION: May polymerize. Avoid contact with incompatible materials.

SECTION 11 TOXICOLOGICAL INFORMATION

CIS-1,2-DICHLOROETHYLENE:
TOXICITY DATA:
13700 ppm inhalation-rat LC50
LOCAL EFFECTS:
Irritant: inhalation, skin, eye
ACUTE TOXICITY LEVEL:

Slightly Toxic: inhalation
TARGET ORGANS: central nervous system
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: respiratory disorders
MUTAGENIC DATA: Available.

SECTION 12 ECOLOGICAL INFORMATION

Not available

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): D001. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: 1,2-Dichloroethylene
ID NUMBER: UN1150
HAZARD CLASS OR DIVISION: 3
PACKING GROUP: II
LABELING REQUIREMENTS: 3

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: 1,2-Dichloroethylene
ID NUMBER: UN1150
CLASSIFICATION: 3
PACKING GROUP: II

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4): Not regulated.

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.40): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):
ACUTE: Yes
CHRONIC: No
FIRE: Yes
REACTIVE: Yes
SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65):
1,2-DICHLOROETHYLENE (ALL ISOMERS)

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65: Not regulated.

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: BD2

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDSL): Not determined.

SECTION 16 OTHER INFORMATION

MSDS SUMMARY OF CHANGES
SECTION 15 REGULATORY INFORMATION

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CH2M HILL HEALTH AND SAFETY PLAN

Attachment 8

Incident Report Forms

CH2M HILL

Incident Report Form (Hardcopy)

Fax completed form to:
425.462.5957
CH2M HILL Seattle Office
Attention: Corporate HS&E Department

Type of Incident (Select at least one)

- ☐ Injury/Illness
- ☐ Environmental/Permit Issue
- ☐ Property Damage
- ☐ Near Miss
- ☐ Spill/Release
- ☐ Other

General Information (Complete for all incident types)

Preparer's Name: _____ Preparer's Employee Number: _____
Date of Report: _____ Date of Incident: _____ Time of Incident: _____ am/pm

Type of Activity (Provide activity being performed that resulted in the incident)

- ☐ Asbestos Work
- ☐ Confined Space Entry
- ☐ Construction Mgmt- Haz Waste
- ☐ Construction Mgmt - Non-Haz Waste
- ☐ Demolition
- ☐ Drilling-Haz Waste
- ☐ Drilling-Non Haz Waste
- ☐ Drum Handling
- ☐ Electrical Work
- ☐ Excavation Trench-Haz Waste
- ☐ Excavation Trench-Non Haz
- ☐ Facility Walk Through
- ☐ General Office Work
- ☐ Keyboard Work
- ☐ Laboratory
- ☐ Lead Abatement
- ☐ Motor Vehicle Operation
- ☐ Moving Heavy Object
- ☐ Other (Specify) _____
- ☐ Process Safety Management
- ☐ Tunneling
- ☐ Welding
- ☐ Wetlands Survey
- ☐ Working from Heights
- ☐ Working in Roadways
- ☐ WWTP Operation

Location of Incident (Select one)

- ☐ Company Premises (CH2M HILL Office: _____)
- ☐ Field (Project #: _____ Project/Site Name: _____ Client: _____)
- ☐ In Transit (Traveling from: _____ Traveling to: _____)
- ☐ At Home

Geographic Location of Incident (Select region where the incident occurred)

- ☐ Northeast
- ☐ Southeast
- ☐ Northwest
- ☐ Southwest
- ☐ Corporate
- ☐ Canadian
- ☐ Asia Pacific
- ☐ Europe Middle East
- ☐ Latin America

If a CH2M HILL subcontractor was involved in the incident, provide their company name and phone number: _____

Describe the Incident (Provide a brief description of the incident): _____

_____

_____

Injured Employee Data (Complete for Injury/Illness incidents only)

If CH2M HILL employee injured
Employee Name: _____ Employee Number: _____

If CH2M HILL Subcontractor employee injured
Employee Name: _____ Company: _____

Injury Type

- ☐ Allergic Reaction
- ☐ Amputation
- ☐ Asphyxia
- ☐ Bruise/Contusion/Abrasion
- ☐ Burn (Chemical)
- ☐ Burn/Scald (Heat)
- ☐ Cancer
- ☐ Carpal Tunnel
- ☐ Concussion
- ☐ Cut/Laceration
- ☐ Dermatitis
- ☐ Dislocation
- ☐ Electric Shock
- ☐ Foreign Body in eye
- ☐ Fracture
- ☐ Freezing/Frost Bite
- ☐ Headache
- ☐ Hearing Loss
- ☐ Heat Exhaustion
- ☐ Hernia
- ☐ Infection
- ☐ Irritation to eye
- ☐ Ligament Damage
- ☐ Multiple (Specify)

_____

- ☐ Muscle Spasms
- ☐ Other (Specify)

_____

- ☐ Poisoning (Systemic)
- ☐ Puncture
- ☐ Radiation Effects
- ☐ Strain/Sprain
- ☐ Tendonitits
- ☐ Wrist Pain

Part of Body Injured

- ☐ Abdomen
- ☐ Ankle(s)
- ☐ Arms (Multiple)
- ☐ Back
- ☐ Blood
- ☐ Body System
- ☐ Buttocks
- ☐ Chest/Ribs
- ☐ Ear(s)
- ☐ Elbow(s)
- ☐ Eye(s)
- ☐ Face
- ☐ Finger(s)
- ☐ Foot/Feet
- ☐ Hand(s)
- ☐ Head
- ☐ Hip(s)
- ☐ Kidney
- ☐ Knee(s)
- ☐ Leg(s)
- ☐ Liver
- ☐ Lower (arms)
- ☐ Lower (legs)
- ☐ Lung
- ☐ Mind
- ☐ Multiple (Specify)

_____

- ☐ Neck
- ☐ Nervous System
- ☐ Nose
- ☐ Other (Specify)

_____

- ☐ Reproductive System
- ☐ Shoulder(s)
- ☐ Throat
- ☐ Toe(s)
- ☐ Upper Arm(s)
- ☐ Upper Leg(s)
- ☐ Wrist(s)

Nature of Injury

- ☐ Absorption
- ☐ Bite/Sting/Scratch
- ☐ Cardio-Vascular/Respiratory System Failure
- ☐ Caught In or Between
- ☐ Fall (From Elevation)
- ☐ Fall (Same Level)
- ☐ Ingestion
- ☐ Inhalation
- ☐ Lifting
- ☐ Mental Stress
- ☐ Motor Vehicle Accident
- ☐ Multiple (Specify)

_____

- ☐ Other (Specify)

_____

- ☐ Overexertion
- ☐ Repeated Motion/Pressure
- ☐ Rubbed/Abraded
- ☐ Shock
- ☐ Struck Against
- ☐ Struck By
- ☐ Work Place Violence

Initial Diagnosis/Treatment Date: _____

Type of Treatment

- ☐ Admission to hospital/medical facility
- ☐ Application of bandages
- ☐ Cold/Heat Compression/Multiple Treatment
- ☐ Cold/Heat Compression/One Treatment
- ☐ First Degree Burn Treatment
- ☐ Heat Therapy/Multiple treatment
- ☐ Multiple (Specify)

_____

- ☐ Heat Therapy/One Treatment
- ☐ Non-Prescriptive medicine
- ☐ None
- ☐ Observation
- ☐ Other (Specify)

_____

- ☐ Prescription- Multiple dose
- ☐ Prescription- Single dose
- ☐ Removal of foreign bodies
- ☐ Skin Removal
- ☐ Soaking therapy- Multiple Treatment
- ☐ Soaking Therapy- One Treatment
- ☐ Stitches/Sutures
- ☐ Tetanus
- ☐ Treatment for infection
- ☐ Treatment of 2nd /3rd degree burns
- ☐ Use of Antiseptics – multiple treatment
- ☐ Use of Antiseptics – single treatment
- ☐ Whirlpool bath therapy/multiple treatment
- ☐ Whirlpool therapy/single treatment
- ☐ X-rays negative
- ☐ X-rays positive/treatment of fracture

Number of days doctor required employee to be off work: _____

Number of days doctor restricted employee's work activity: _____
Equipment Malfunction : Yes ☐ No ☐ Activity was a Routine Task: Yes ☐ No ☐
Describe how you may have prevented this injury: _____
_____

Physician Information
Name: _____
Address: _____
City: _____
Zip Code: _____
Phone: _____

Hospital Information
Name: _____
Address: _____
City: _____
Zip Code: _____
Phone: _____

Property Damage (Complete for Property Damage incidents only)

Property Damaged: _____ Property Owner: _____
Damage Description: _____
Estimated Amount: $ _____

Spill or Release (Complete for Spill/Release incidents only)

Substance (attach MSDS): _____ Estimated Quantity: _____
Facility Name, Address, Phone No.: _____
Did the spill/release move off the property where work was performed?: _____
Spill/Release From: _____ Spill/Release To: _____

Environmental/Permit Issue (Complete for Environmental/Permit Issue incidents only)

Describe Environmental or Permit Issue: _____
Permit Type: _____
Permitted Level or Criteria (e.g., discharge limit): _____
Permit Name and Number (e.g., NPDES No. ST1234): _____
Substance and Estimated Quantity: _____
Duration of Permit Exceedence: _____

Verbal Notification (Complete for all incident types)(Provide names, dates and times)

CH2M HILL Personnel Notified: _____
Client Notified: _____

Witnesses (Complete for all incident types)

Witness Information (First Witness)
Name: _____
Employee Number (CH2M HILL):_____
Address: _____
City: _____
Zip Code:_____
Phone: _____

Witness Information (Second Witness)
Name: _____
Employee Number (CH2M HILL: _____
Address: _____
City: _____
Zip Code:_____
Phone :_____

Additional Comments: _____
_____